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BIOLOGY.—*Integration and individuation as elements of evolution.* A. A. WILLIAMSON, Washington, D. C. (Communicated by Waldo L. Schmitt.)

If we could first know where we are, and whither we are tending, we could better know what to do, and how to do it.—ABRAHAM LINCOLN

In a paper entitled *Speculation on the cosmic function of life* (Journ. Washington Acad. Sci. **43** (10). 1953), a schematic concept of biological evolution, therein called the pyramid of life concept, was outlined. Its essence is that biological evolution is factually progressive by objective criteria, empirically verifiable. Progress was shown as marked by the successive superimposition of one level (category) of life upon an earlier evolved one from which it so derives food or sustenance that a consequent diminution of comparative aggregate number, level by level, necessarily results, but no contraction of aggregate territorial dominion, which in every case is or becomes world wide in extent. Source of sustenance is thus made the primary criterion of evolutionary superiority. On this basis sustenance consumers are higher in nature's scheme of things than their sustenance suppliers, but the latter are given an irreversible priority of importance by their sustenance-supplier status. The over-all process registers progress because it works consistently toward a discernible End or Objective: the pyramid's adumbrated apex of numerical singularity in an eventual World Order of human national social organizations regionally or culturally associated as political units sustaining it. (It is axiomatic that progress per se is distinguished by movement toward some specific end or objective.)

The Pyramid of Life Concept has broad human interest and high philosophical import because it reveals meaning in the evolution of life such as understandings of that process do not now have and the very possibility of which is often categorically denied. Despite any and all objections that may be raised against the concept, it may confidently be said that the pyramid itself is undeniably factual, while the concept's primary assumptions are so incontrovertible as to admit of no arguments contra. In its natural history and its scientific aspects it is so grandly comprehensive as to include both the esthetic and the theoretic components of things and our knowledge of them which Prof. Filmer S. C. Northrop has shown to be fundamental to philosophy, religion, and civilization. From its postulates can be drawn axioms, theorems, and propositions which are subject to detailed development. Moreover, by a speculative but not groundless extension, it can be given cosmic scope, which highlights the complete irrelevance of objections that living things are not closed systems. (They could not *process*—concentrate, refine, and relay—energy if they were.)

In addition, the concept seems to offer what may be the best philosophical justification for the democratic political system found since Berkeley and Hume exploded the Lockean philosophy so strongly reflected in our Declaration of Independence and our Constitution with its tripartite departmentalization of government. This justification is harmonious with the "gametic interpretation of history" proposed by Frederick Adams Woods when lecturer in biology in the Massachusetts Institute of Technology as an outcome of the application of his scientifically devised method of measuring historical causation, by him called historiometry, although it carries that inter-

pretation beyond the intentionally limited scope of his inquiry.[1]

In the JOURNAL paper above referred to it was possible only to sketch the concept in barest outline. No discussion could be introduced of two great trends, principles, or forces which—well known though they are—can not be known in their true significance unless their relation to the pyramid-building process is seen. To indicate that relation is the purpose of this paper.

These two principles or forces often appear to be mutually antagonistic but they are actually interacting and complementary. In this paper they will be called the Organic or Integrative Principle (Principle A) and the Individuative or Independence Principle (Principle B). Since they are already often referred to in the same or comparable terms, no difficulty should arise in understanding what they mean. By the operation of Principle A, evolved exemplars of Principle B are combined to form more complex biological units as well as higher levels of life.

While analogous principles operate in the inanimate world (e.g., chemical valence and such phenomena as the carbon and nitrogen cycles) to form the physical foundation of the pyramid of life and supply its material necessities, this discussion may conveniently start with life in unicellular form.

At the level of unicellular life, then, Principle A has already produced individuals which, in the great majority of cases, reflect the operation of Principle B by asserting and constantly endeavoring to maintain a self-sufficiency which resists all occasions and opportunities for joint, cooperative union with others of their kind if it requires subordination by restrictive specialization of function. Hence it is characteristic of the products of Principle A that upon attaining B status as individuals, competition is engaged in and any further unifying organization is rejected. To maintain their independent individuality is their main business in life. Nevertheless, there were exceptions to this rule. Through these exceptions, multicellular life began.

[1] Dr. Wood's work seems strangely unfamiliar to professionals in the social sciences and the humanities. See footnote 10.

Biological evolutionary progress appears always to involve particularity. It seems to have to wait upon the appearance of particular forms of life which lend themselves or are amenable to the operation of Principle A, the organizing principle. In his 1942 volume, *Evolution, the modern synthesis*, Julian Huxley says on page 558 that progress "may just as well prove to be partial as universal." But on the basis of the Pyramid of Life Concept it *has to be* partial. For every higher stratum of the pyramid depends for its existence upon the prior and continued existence of its immediately antecedent, evolutionarily inferior, and sustenance-supplying stratum. This *necessitates* a fixed evolutionary position for all such levels. Accordingly, not only unicellular life but also the vegetal, herbivorous, and carnivorous levels of life have been perpetuated "unto this day."

In a chapter on "Darwinism Today" in his book *Man in the modern world*, Huxley further states: "The single organism, looked at through evolutionary spectacles, has no meaning except in relation to a particular environment, to a particular set of enemies and competitors, to a particular past history, and to a particular set of potentialities for the future."[2] In this one sentence the word, particular, occurs no less than four times, but—for present purposes—it has greatest significance when it relates to "a particular set of potentialities for the future." In the sense of this paper that means when an organism in amenable to the operation of Principle A.

In a highly interesting article in the Atlantic Monthly for February 1946, under the caption "The Social Animal," the distinguished biologist Dr. Caryl P. Haskins, in collaboration with his wife, Edna F. Haskins, traces the evolutionary steps leading to the production of societies at different levels. He says: "On the basis of this single example [the alcoholic fermentation of sugar as performed by yeasts in the ripening of wines and spirits], which can be multiplied manyfold, we may tentatively accept the view that, in certain aspects, the single cell too is a society, to which certain of the concepts of

[2] Mentor Books, no. M31, p. 176.

societies can be properly applied." Thus, even in the single cell, as already noted, Principle A has operated to produce exemplifications of Principle B; namely, individuals—with social connotations. In certain specific cases, these have been used for the further operation of Principle A.

In the same Atlantic Monthly article, Dr. Haskins shows how multicellular forms of animal life have most probably been evolved, "to culminate at last in the vertebrates. There specialization of the cellular components has become so finely developed, there the individuality of the colony has been so exaggerated at the expense of its once independent parts, that we no longer think of these colony-animals—these flamingos or these elephants or these men—as cellular communities at all." For the individuating principle (Principle B) has quite definitely claimed them for its own.

In the same article Dr. Haskins further states: "Every 'society' that we can name, at any level of life, shows in its evolution, and particularly in its inception, a well-marked trend to proceed from a simple to a more complex state." And he adds: "Purely on the basis of Darwinian natural selection, on the theory of 'the survival of the fittest,' it is not easy to understand why this unmistakable trend from the simple to the complex should be universal in the evolution of earthly societies. Over and over again we have vivid evidence that the advance from a solitary to a social existence cannot, in its early stages, have been wholly beneficial to the species in the sense that its survival value was increased relative to its competitors." He reenforces this by saying: "Every evidence seems to indicate that the first transition from the solitary to the colonial mode of life *was not an expedient move.*" (Italics supplied.) For no immediate competitive advantage could be seen to have accrued from that transition but, rather, the contrary. If, however, we can conceive of the whole evolutionary process as working through successive diminution of number toward a discernible End (the pyramid's eventual unitary apex), we can see in these evolutionary steps the complementary, interacting operation of Principles A and B, organizing, establishing, organizing again and again establishing in methodical repetition. Only in this way is the major (i.e., the realm by realm) progress of evolution achieved. But in this way it is achieved, and achieved systematically.

In his outstanding work on this general subject,[3] Dr. Haskins develops his studies in detail, tracing "significant trends in the formation, the growth, and the duration of societies, notably those of men," as the jacket announcement summarizes it. He distinguishes between the closely integrated, caste-system type of social organization exemplified by insect (single family) societies and the loose, "associative" (herding) type common among vertebrates. Dr. Haskins holds societies to be organisms only by analogy, differentiating between biological man and cultural man: "The linchpin joining the biological social structure and man's cultural society in that intimate union called civilization is the human mind."[4] Historically, they are as inseparable as psyche and soma, for man's great evolutionary achievement was to create family-associative societies psychologically unified and organically articulated by group subservience to what were in essence (*as they still are*) concepts of nature plausible enough to win paramount human devotion. As Haskins puts it: "... it is frequently the associative structure and not the family which commands the highest loyalty of men."[4] (This is not yet wholly true in the Far East.)

It has been said that life and mind are correlates. The distinguished Indian physicist, Sir Jagadis Chandra Bose, showed in a series of experiments that, as far as we can discover, plant response to excitations of various kinds parallels if it does not accord fully with animal tissue response, the notable differences being such as could be attributed to structural differences. While differences in animal mentality are enormous, it is arguable that they are essentially a matter of degree. Neither absolute nor relative brain weight is a sure measure of intelligence in man or animal, but its use

[3] *Of societies and men*. Introduction by Vannevar Bush. W. W. Norton, New York, 1951.

[4] *Of societies and men*, pp. 208 and 178, respectively.

to create cultures and civilizations makes man unique.

Insect life is, indeed, governed almost wholly by what we call instinct, but there is abundant evidence that many warm-blooded animals display intelligence in their reactions to the exigencies of their mode of life. And predatory carnivores as a class constantly show a mentality superior to that of their herbivorous prey. The predatory habit makes that mandatory.

When, in the pyramid-constructing process, the carnivorous animal level had been established, then the sustenance-supplying potentialities of the mineral kingdom, of vegetation, and of animal matter had been thoroughly exploited by a great variety of life forms. Consequently, there then remained no way to raise the pyramid to higher levels by the same source-of-sustenance criterion except to exploit the sustenance-supplying potentialities of mentality. This was done through the evolvement of societies.

Now, mere size is in many ways a biological factor, as Huxley, Schrödinger,[5] Haskins, and others have noted. And so, although insects were the first to evolve true societies showing in many ways a remarkable use of mentality, they simply could not fulfill nature's evolutionary requirements for pyramid-constructing purposes, for they could not wrest evolutionary supremacy from the carnivores. Only man has met those requirements, and by his superlative power to exploit the only remaining source of sustenance—mentality. It is, indeed, *as if* evolution had been preparing for this eventuality from the very beginning as it built up the vegetal and the herbivorous and carnivorous animal levels of the pyramid's physical organismal realm of life. Evolutionarily speaking, this is the raison d'etre of human social organisms, whose source of sustenance is mentality, increasingly developed through the complementary operation of Principles A and B. Man—and man alone—has made mentality supreme.

So powerful, so inherently fixed, is the gregarious impulse in man that he seems never to have existed as a solitary animal. Always he is found to be a social animal. And social living, with its manifold contacts and associations, inevitably requires commonly accepted norms of conduct and ways of thought. In their complex interrelations, these constitute what we call culture. No established human group has ever been known that did not have its culture, always institutionally embodied. Such institutions are analogs of the specialized parts of physical organisms. They make cultures organic: as their organs, they rule the life of man. Yet mind-generated movements can change them if philosophically required. For, as Frederick Watkins has said: "In the long run . . . no movement can evoke the fullest energies of its supporters unless it offers them an adequate justification for the things they are doing."[6] And no such justification is adequate unless it reflects the scientific knowledge of the time, which itself changes with time.

Sociologically speaking, culture and civilization do not differ essentially, civilization merely being culture in a more or less advanced (complex) stage of development. Nevertheless it can be said that here, too, size is a factor. Systematic agriculture has been and still is the invariable basis of civilization. Historically, it fixed cultures in permanent locations, provided an abundant and dependable food supply, promoted population increase, and encouraged if it did not require the building of cities, which have become the hallmark of civilization. Yet it is highly improbable that advances toward civilization could have been made as they have been made if man had been unable to communicate ideas through the media of language and symbols, and to develop what has become, perhaps, the greatest civilizer of all: the invention and use of tools.

As Haskins has emphasized, what he calls "margins of vitality"[7] play an indispensable part in the advance of culture as civilization. Representing as they do the accumulation and exploitation of conserv-

[5] *What is life?* Cambridge University Press, 1944. Reprinted 1945, 1948, 1951, with a note to chapter 6.

[6] *The political tradition of the West*, p. 358. Harvard University Press, 1948.

[7] Op. cit., p. 231 et seq.

able, need-supplying surpluses, both material and ideational in character, their number and complexity very largely determine the height of civilization attainable by any specific culture. Since, however, the elements of culture in its various stages are often transmissible, a civilization may become widely established geographically under favorable conditions.

As defined by the Dictionary of Sociology,[8] "The true nation is probably the most stable and coherent large-scale human group yet produced by social evolution," and a nation is "A nationality that has achieved the final stage of unification represented by its own political structure and territorial establishment." Further: "A true nationality is animated by consciousness of kind and has a fundamental similarity in its mores." Parenthetically, a nationality is never a nation unless it dominates territory, as all living things must do.

The operation of Principles A and B is plainly observable in human history. All the earlier civilizations, of both the Old World and the New, exhibited national organization of the closely integrated, caste-system type, analogous to that of the social insects. In these early stages, social status and opportunity to exercise intelligence were determined almost entirely by birth.[9] And, as Frederick Adams Woods has shown historiometrically, the political and economic prosperity of absolute European monarchies, including Turkey, almost invariably depended directly on and quickly reflected the character and abilities of the reigning sovereign. These—good, bad, or indifferent—he found to be gametically determined. Of the two biological factors, inheritance and environment, the first was shown to be far more powerful. Nevertheless, from time to time, superior intellects from without the pale occasionally appeared and seized the prize of power or founded a line of heredity which was able to do it.[10]

It was, of course, in ancient Greece that the idea of freedom and liberty first arose and found expression in the democratic political system. This led directly to a great outburst of intellectual activity and accomplishment such as had never before been seen and to which we are deeply indebted even today. But modern democracy derives more from the assemblies of the Teutonic peoples, especially the Witenagemot of the Anglo-Saxons, than from Greece and Rome.

It is the peculiar glory of the democratic political system that it removes restrictions which so long had held to a minimum the operation in human history of that third biological factor, genetic recombination and mutation. By that removal the doors of opportunity are opened to all without discrimination. It thus makes socially available all those superior mentalities of varying degree which can and do arise in any and all levels of society by whatever criterion and to which the world owes much. Without it civilization in its more advanced stages (i.e., mechanized industry) cannot flourish. This third biological factor can be assured full and free play only by the democratic system. To quote again from Frederick Watkins: "If the maximization of human potentialities is the ultimate secular value, and if the realization of that value depends on the maintenance through legislation of optimum social conditions, it follows that political action is an indispensable part of the moral responsibility of men."[11] It is to be noted that "the ultimate secular value" specified is only negatively hedonistic—"a calculus of pleasure and pain." Positively, it aims at the utmost possible state of societal homeostasis.

From the viewpoint of this paper, what the democratic political system does is to make nations successfully adopting it more truly and thoroughly psychozoic organisms because it permits them to draw mental and spiritual sustenance from *all* their human sustainers instead of from a restricted segment of them only. Ideally, every citizen has full opportunity—and is, indeed, expected—to make his contribution by the

[8] Philosophical Library, Inc., New York, 1944.

[9] Under such a system Sir Isaac Newton, as the son of a small farmer, would himself have been compelled to be a small farmer without hope of ever being anything else.

[10] *Mental and moral heredity in royalty*. Henry Holt, New York, 1906. *The influence of monarchs*. Macmillan, New York, 1913.

[11] Op. cit. supra, p. 251.

discovery (including the self-discovery) and the development of his mental endowments. It is the unpredictability of individual human potentialities which gives such value to the democratic high regard for the sanctity of the individual person, his rights and liberties. But these carry with them political and social duties and responsibilities which are, alas, less often stressed.

It is now recognized in philosophical circles if not elsewhere that what the democratic political system actually does is to hold in operational balance at the human national societal level those two great evolutionary trends, forces, or principles here called the Organic or Integrative Principle (Principle A) and the Individuative or Independence Principle (Principle B).[12] That level constitutes the first true level of the psychozoic organismal realm of the grand, mammalian pyramid of life, that realm of life in which evolutionary progress at last makes mind, mentality, or intellect supreme.

The freeing of the mind as only democracy can free it, to range wherever it will, is the best guarantee humanity can have that mass intelligence will sooner or later come to reign over mass emotion and hold it in control throughout the world. It is therefore the best guarantor of eventual world peace.

In a broad, general way, then, it can truthfully be said that the two interacting, complementary principles herein discussed operate in the over-all biological evolutionary process and are essential to it. Only when that is perceived do we realize that they have made and still make possible the successive superimposition of level on level in the pyramid of life to which man and his cultures and civilizations belong. For they can be seen to be operative in human history precisely as they have operated in earlier times on subhuman forms of life.

One of these principles (Principle A) has operated to bring animate nature (life) out of the insensate world of matter; to transmute unicellular forms into multicellular organisms; and to produce insect and human societies. Cooperation is its "keynote."

The other principle (Principle B) has operated to establish and perpetuate the various successive levels of the pyramid as they emerged and proved their power to exist. Its "keynote" is competition involving Darwinian natural selection.

Without the complementary operation of these two principles the construction of our pyramid of life—or any other—would not have been possible. It is because they have operated that our pyramid is as it now stands, visible around us wherever we may be.

Today, in current history, the creative operation of Principle A seems clearly evident. Despite all anathemas against it, the spirit of nationalism is spreading in the Far East, where cultural tradition neither induces nor fosters it yet where even democracy is being attempted. In the West, the competition of antagonistic doctrines is compelling the democratic nations to organize, as in the North Atlantic Treaty Organization, here held to be symptomatic of what will slowly develop everywhere to form a pyramidal level of regional supranational organizations if not organisms, all in antecedence to a still higher level to constitute in actuality what is now but the logically adumbrated apex of the pyramid as a unitary World Order.

Thus does the Pyramid of Life Concept, schematically reflecting biological evolutionary principles, illuminate human history prophetically by its revelation of meaning therein—a meaning, moreover, which is "publicly valid" in the sense of holding good at all times for all men everywhere. Nor are future refinements in evolutionary theory likely ever to diminish that validity, for it is rendered independent of detail by the breadth of its outline, the grandeur of its scope.

They are one with evolution itself.

[12] Northrop, F. S. C.: *The meeting of East and West*. Macmillan, New York, 8th printing, p. 191, 1951. Also Haskins, op. cit. supra, p. 260f.

Grateful acknowledgment for permission to quote at some length from their designated publications is made to the following: The Atlantic Monthly, W. W. Norton & Co., Inc., Harvard University Press, and Philosophical Library, Inc.

BIOCHEMISTRY.—*Differential media for* Escherichia coli *and* Aerobacter aerogenes. H. J. FERLIN and J. V. KARABINOS, Blockson Chemical Co., Joliet, Ill.

Clapper and Poe (1947) described the utilization of various organic acids as the sole source of carbon for possible differentiation of members of the *Colon-aerogenes* group. They suggested that propionic acid could support the growth of 11 out of 18 strains of *Escherichia coli* to the exclusion of *Aerobacter aerogenes*. However, the three strains of *A. aerogenes* used in this research grew quite well on their media, and no differentiation was observed.

More recently, Johnson and Cohn (1952) demonstrated that fumaric and malic acids stimulated the growth of *E. coli*.

Certain observations in this laboratory indicated that the citrate agar of Simmons (1926), an improvement over Koser's (1924), citrate medium deserved further study. It seemed logical to investigate related organic acids, particularly those of the Krebs-cycle, in a similar manner for possible differentiation of these organisms.

MATERIALS AND METHODS

Two solutions of inorganic salts were prepared and sterilized. One contained 1.5 percent $NaNH_4HPO_4$ and 1 percent KH_2PO_4, the other contained 0.2 percent $MgSO_4 \cdot 7H_2O$. Both solutions were diluted tenfold in order to obtain the desired concentration.

For the citrate media, all concentrations herein expressed are in terms of the acid monohydrate. Thus, 0.2 percent of Simmons's sodium citrate is equivalent to about 0.06 percent of citric-acid monohydrate as used in the present study. However, the citrate agar of Simmons was prepared in accordance with his methods. All the other media were prepared by dissolving various concentrations of the respective acid in the salt solutions so that these portions of the media represented twice the desired final concentration. Sodium chloride, where used, was also incorporated into the above portions of the media. The pH was then adjusted as desired. The agar was prepared separately, a 4 percent concentration being made. The two were sterilized separately, then combined in equal amounts just prior to use. Once the two were combined, plates were poured immediately. Increasing acidity and/or increasing concentrations of sodium chloride tended to hydrolyze the agar to a point where it would not solidify. After combination the pH of a small aliquot was verified with a Beckman pH meter at a temperature of 55°C.

The other acids were prepared in a similar manner. The concentrations are all expressed in terms of the acid used; no correction was made for loss of any volatile acids.

Organisms used were *Escherichia coli* ATCC #11229, three cultures of *Aerobacter aerogenes*, four cultures of *E. coli* of endogenous origin, *E. intermedium*, ATCC #6750, *E. coli* var. *communior* ATCC #4352, and *Serratia marcescens*.

RESULTS AND DISCUSSION

Citric-acid media were studied in the following manner. The pH, sodium-chloride concentration, and acid concentration were varied in order to find the optimal conditions for growth of *Aerobacter aerogenes* and inhibition of *Escherichia coli*. It was found that on Simmons's citrate agar alternate streaks of *A. aerogenes* and *E. coli* resulted in rapid development of *A. aerogenes* colonies followed by symbiotic growth of *E. coli*

TABLE 1.—EFFECT OF SODIUM CHLORIDE CONCENTRATION ON GROWTH OF A. AEROGENES AND E. COLI

	0.3% Citric No NaCl				0.3% Citric 0.2% NaCl				0.3% Citric 0.4% NaCl				0.3% Citric 1% NaCl				0.3% Citric 1.5% NaCl				0.3% Citric 2.0% NaCl			
Time (hrs.)	24		48		24		48		24		48		24		48		24		48		24		48	
pH	6.0	6.8	6.0	6.8	6.0	6.8	6.0	6.8	6.0	6.8	6.0	6.8	6.0	6.8	6.0	6.8	6.0	6.8	6.0	6.8	6.0	6.8	6.0	6.8
Aerobacter aerogenes	4+	4+	4+	4+	4+	4+	4+	4+	4+	3+	4+	3+	4+	3+	4+	3+	3+	3+	4+	3+	2+	2+	3+	2+
Escherichia coli	−	−	−	−	−	−	−	−	−	−	−	−	−	±	±	±	±	+	+	+	+	2+	+	2+

(−), no growth; (±), doubtful growth; (+), growth; (2+), moderate growth; (3+), good growth; (4+), luxuriant growth.

after an initial delay. The closer the streaks of *E. coli* were placed to *A. aerogenes*, the shorter was the time lapse required for growth of the former.

The action of sodium-chloride concentration was found to vary with the pH but was not materially affected by varying concentrations of citrate. For example, though 0.06 percent citric acid monohydrate gave much poorer growth of *A. aerogenes* than did 0.3 percent, the growth with any given concentration of sodium chloride at any given pH was proportional. There was considerable evidence that increasing concentrations of sodium chloride not only inhibited *A. aerogenes* (Table 1) but actually tended to aid the growth of *E. coli* on the medium. Whether this is actually due partly to hydrolysis of the agar is uncertain.

It therefore seemed desirable to eliminate sodium chloride from the medium. Although the above table shows only 0.3 percent citric acid, the results were similar with other concentrations.

At various concentrations of salt and citrate, the pH of the media was varied from 5.5 to 7.5 at intervals of 0.2 unit. At a pH of 5.8–6.2 (6.0 is apparently optimal) the best and most luxuriant growth of *A. aerogenes* was obtained with no apparent growth of *E. coli*. This was true regardless of the concentration of citric acid employed in the series.

Finally the citrate concentration was varied. It was found that growth of *A. aerogenes* was optimal with a concentration of about 0.3 percent citric acid monohydrate. When the concentration was increased much beyond this point, *E. coli* began to develop. At a concentration of 0.5 percent citric acid the growth of *E. coli* was doubtful, but at 1 percent it was definitely present. Although decreasing concentrations of citrate failed to support growth of *E. coli*, growth of *A. aerogenes* was much poorer and often failed to occur.

Combination of these optimal conditions, namely 0.3 percent citric acid, no sodium chloride, and a pH of 6.0, were compared with Simmons's citrate agar. Streaking for purposes of isolating *A. aerogenes* from *E. coli* showed no apparent differences between the modified medium and Simmons's citrate agar. However, the new medium did give more luxuriant growth.

By diluting mixed cultures of the two organisms and using a plate count technique, colonies selected at random from this new agar were less prone to consist of mixtures of *E. coli* and *A. aerogenes* than those selected from Simmons's citrate agar. In Table 2 are shown results obtained with a mixture of approximately equal numbers of *E. coli* and *A. aerogenes*. These were 24-hour cultures combined just prior to use. A 10^{-6} dilution was made of the mixed organisms and these were plated out using the two media. After 48 hours incubation at 37°C., the colonies were counted and isolated colonies were removed with a needle and subcultured in nutrient agar. These were then tested for indole and acetylmethyl carbinol production and for their methyl red reaction. Nutrient agar control counts were also carried out. A 10^{-6} dilution gave approximately 400 colonies.

Forty isolates from two plates of Simmons's citrate agar were made, and 80 isolates from two plates of the modified medium. All isolates from Simmons's citrate agar gave positive acetylmethyl carbinol tests indicating that they contained at least some *A. aerogenes*. The fact that 20 percent were methyl red positive and 30 percent were indole positive indicated that up to 30 percent of the isolates were mixtures. On the other hand, the results with the new agar demonstrated that although all the isolates contained *A. aerogenes* only five percent of these were apparently mixtures.

Two methods were used to determine indole production, the standard method using ether extraction followed by Ehrlich's reagent, and an alternate procedure developed here, a report of which will be made at a later date.

The possible advantages of this new citrate agar is demonstrated predominantly by the plate count tests. The only other method of demonstrating its advantages is by the luxuriance of growth mentioned earlier.

Serratia marcescens and *Escherichia interme-*

TABLE 2.—REACTIONS OF ORGANISMS ISOLATED BY PLATE COUNT METHOD

	Simmons's Citrate Agar (0.5% NaCl) pH 6.8	Citrate Agar 0.3% Citric Acid Monohydrate (No NaCl) pH 6.0
No. of Colonies/Plate	20	150
Indole	70% (−)[a]	95% (−)[a]
	30% (+)	5% (+)
Acetylmethyl carbinol	100% (+)[b]	100% (+)[b]
Methyl Red	20% (+)[c]	0% (+)[c]
	80% (−)	100% (−)

[a] (−) indicates indole negative, (+) indole positive; [b] (+) indicates production of acetylmethyl carbinol; [c] (+) indicates pH 4.5 or less, (−)pH greater than 4.5.

dium also grew well on the modified medium. This citric acid medium can also be prepared by combining all ingredients in the desired proportions, including the agar, followed by the customary autoclaving.

Incorporation of bromthymol blue into this citrate agar was useful in demonstrating an alkaline reaction. However, luxuriance of growth obviates its use in this medium.

Other acids of the Krebs cycle tested for possible differentiation of these members of the colon-aerogenes group were acetic, pyruvic, malic, fumaric, succinic, and aconitic. With the exception of fumaric acid, none showed any apparent ability to differentiate the organisms. Butyric and propionic acids were likewise found unacceptable. Maleic acid, although a steroisomer of fumaric, could not be induced to support more than a doubtful growth under any of the conditions tried. Fumaric gave indications of supporting growth of *E. coli* to the exclusion of *A. aerogenes* early in this work. While subsequent developments tend to indicate it is not completely acceptable as a differential medium, it appears to be useful to some extent. After considerable experimentation with regard to sodium-chloride concentration, fumaric acid concentration, and pH, the most desirable medium was found to consist of 0.5 percent fumaric acid, 1 percent sodium chloride, and a pH of 5.6 to 6.0 with 5.8 apparently optimal. Using this medium, it was found that by streaking with *E. coli* and *A. aerogenes* and incubating at 37°C. *E. coli* consistently gave well-developed colonies in 18–24 hours, while *A. aerogenes* failed to give a recognizable growth until 28–44 hours. This lag of 10 to 20 hours by *A. aerogenes* was found to occur consistently regardless of the strains used. However, because of slight variations it is recommended that controls of pure cultures be used with each fresh batch of medium. *E. intermedium* and *S. marcescens* gave growth very similar to *A. aerogenes* and could also be differentiated from *E. coli*.

Because of the pH and salt concentration, the agar must be autoclaved separately from the rest of the fumaric acid medium or it fails to solidify, Plates must be poured immediately after the agar and medium have been combined. The primary cause of variations mentioned previously was apparently due to the length of time the mixture was maintained at elevated temperatures. Best results were obtained when the two were cooled to about 45°–50° C., mixed, and plates poured immediately thereafter.

By using a plate count technique, as with the citric acid media, isolated colonies were removed and subcultured in nutrient broth. However, under these circumstances the optimal incubation time was found to be from 42–48 hours apparently because of more nearly anaerobic conditions. Of 80 colonies isolated, 90 percent were found to be pure cultures of *E. coli*. After 72 hours of incubation with fumarate agar, the pure cultures of this organism dropped to 60 percent and after 96 hours to 20 percent.

Again, as with citrate agar, mixtures of *E. coli* and *A. aerogenes* were streaked and after 18–22 hours incubation isolated colonies were subcultured in nutrient broth; over 90 percent were found to be mixtures of the two organisms. It was of interest that *E. coli* var. *communior* would not grow on any of the above-mentioned media.

SUMMARY

Various conditions for the improvement of citrate agar for differentiating *Aerobacter aerogenes* from *Escherichia coli* were studied. It was found that by eliminating sodium chloride from the medium, increasing the concentration to 0.3 percent in terms of citric-acid monohydrate, and adjusting the pH to 6.0 better growth of *A. aerogenes* was obtained. Using a plate count method to isolate the colonies indicated that this medium gave more luxuriant growth of *A. aerogenes* with greater exclusion of *E. coli*. Streaking did not demonstrate this because of an apparently symbiotic growth.

A fumarate agar containing 0.5 per cent fumaric acid, inorganic salts, 1 per cent sodium chloride, and 2.0 per cent agar was found to give growth of *A. aerogenes* consistently delayed 10 to 20 hours behind *E. coli* when the plates were streaked. Pour plates required 40–48 hours incubation for development of *E. coli*, while 60–72 hours incubation were required for *A. aerogenes*. By means of the plate count technique it also was found that 40- to 48-hour cultures could be used for isolation of *E. coli* from *A. aerogenes* in mixtures containing approximately equal numbers of the two.

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PALEONTOLOGY.—*Emendation of the foraminiferal genera* Ammodiscus *Reuss, 1862, and* Involutina *Terquem, 1862.* ALFRED R. LOEBLICH, JR., and HELEN TAPPAN, U. S. National Museum.

While examining type species of foraminiferal genera, during preparation of the section on Foraminifera for the *Treatise on invertebrate paleontology*, the writers found some genera to be quite incompletely known and incorrectly understood. Inasmuch as some of the early illustrations and descriptions were generalized or inaccurate and some of the type specimens had not since been restudied, this was not surprising. Unfortunately, upon reexamination of the types and the literature some supposedly well-known genera were found to be synonymous with others and quite unlike what was commonly referred to the genus.

Most paleontologists would have stated that the genus *Ammodiscus* Reuss, 1862, was a very well-known genus and that there were no problems as to its type species, generic characters, or systematic position. That the exact opposite is true we have now learned. A century ago taxonomists were not held to as rigid rules of nomenclature as today, and those who deplore the present "arbitrary" and exacting rules would do well to consider the status of many genera and species described before the advent of the International Commission. Today, Reuss's genus would have had no validity, as he mentioned no species, nor did he cite an exact reference to earlier species. This fact led to a later erroneous designation of type species, as will be shown. A century ago, as well as much more recently, Foraminifera were not thought to be sufficiently high in the evolutionary scale to have many diagnostic characters, and forms were considered conspecific even when they had completely different wall composition. Species were placed in a single genus regardless of whether they were attached or free, calcareous, or agglutinated, septate or undivided, and irrespective of the position or even the number of apertures. Many later references to these early species thus may be similar to certain of these early illustrations but are too often completely unlike the original type specimens. In the case of type species for genera this can have far-reaching effects. The type species of the genus *Ammodiscus* is here shown to belong to *Spirillina*, and thus not only does the genus become a junior synonym, but as it belongs to an entirely different systematic position, it must leave the family Ammodiscidae and subfamily Ammodiscinae for which it was considered the type genus.

Genus **Ammodiscus** Reuss, 1862, emended

Original reference.—Sitzb. Akad. Wiss. Wien, math.-nat. Cl., Jahrg. 1861, **44** (Abt. 1): 365. 1862.

Types species.—*Orbis infimus* Strickland, 1846. Fixed by subsequent monotypy: Bornemann (1874, p. 725).

Emended diagnosis.—Test free, discoidal, consisting of a globular proloculus followed by a planispirally coiled or very slightly trochoid tubular second chamber; wall calcareous, composed of a single crystal of calcite, occasionally irregularly fibrous in appearance in cross-section; aperture at the open end of the tube.

Discussion.—Reuss (1862, p. 365) described the genus *Ammodiscus* but named no species in the original reference. In his synonymy he included "*Cornuspira* Will. z. Thl.; *Trochammina* Park. et Jon. z. Thl.," but he mentioned no species within these two genera. Cushman (1910, p. 73) designated *Operculina incerta* d'Orbigny, 1839, Recent of Cuba, as the type species of the genus. Galloway (1933, p. 97) stated "... Reuss said, '*Cornuspira* Will. z. Th; *Trocham-*

mina Park. et Jon. z. Th.' Parker and Jones had the variety *T. squamata incerta* (d'Orb), which Reuss' description fits, and since it was one of original species and has been designated, it is the valid genotype." Parker and Jones (1859, p. 347), in their original description of *Trochammina*, mentioned only *Nautilus inflatus* Montagu but stated that "in deeper water it is represented by attenuated varieties, ultimately becoming *Spirilline*." They cited no "spirilline" species, however. This is perhaps the reference to which Reuss referred in his synonymy, for although he makes no definite citation of this reference under his discussion of *Ammodiscus*, he does cite the reference several times elsewhere in his article. Jones and Parker (1860, p. 304) (n.b. not Parker and Jones) cite the following species under *Trochammina: Rotalia inflata* Montagu (cited as type species), *T. irregularis* (=*Webbina irregularis* d'Orbigny), *T. irregularis alternans*, *T. irregularis clavata* (the type species of *Ammolagena* Eimer and Fickert, 1899), *T. squamata*, *T. squamata incerta* (d'Orbigny) (cited by Cushman, 1910, p. 73, as type of *Ammodiscus* Reuss, 1862), *T. squamata charoides* (a *Glomospira*), *T. squamata gordialis* (type species of *Glomospira* Rzehak, 1888), and *T. squamata inflata*.

Thus Jones and Parker placed under *Trochammina* at least five distinct genera, belonging to at least four different families. This reference is perhaps the one referred to by Galloway (1933, p. 97) inasmuch as it is the only reference of this early date citing *T. squamata incerta* (d'Orbigny). It should be kept in mind, however, that this reference is by Jones and Parker and not Parker and Jones, and thus it is doubtful that Reuss referred to it. Cushman therefore was in error in citing *Operculina incerta* d'Orbigny as type of *Ammodiscus*. As no original species were mentioned by Reuss, Galloway was also in error in stating that since *T. squamata incerta* (d'Orbigny). "... was one of the original species and has been designated, it is the valid genotype." In such a case, where Reuss described the genus *Ammodiscus* without naming a species, the first species to be placed in *Ammodiscus* becomes ipsofacto the type species of the genus and no subsequent designation can alter this fact.

The earliest name used in conjunction with *Ammodiscus* was *Ammodiscus lindahli* Carpenter and Jeffries (1871, p. 160). The only mention of this species, however, was given under the discussion of the dredgings under the report for July 29. Samples were obtained from 364 and 322 fathoms (*Porcupine* stations 26 and 27). They list various mollusks, etc., which were found and state: "But the most remarkable novelty here obtained was a large collection of thin sandy disks, from 0.3 to 0.4 inch in diameter, with a slight central prominence; for these proved on subsequent examination to contain an entirely new type of Actinozoon, extraordinarily flattened in form, and entirely destitute of tentacles. Dr. Carpenter, by whom this curious organism will be described, has assigned to it the name of *Ammodiscus lindahli*." Apparently this mention was not intended to be a specific description as it was stated (p. 161), "The quantity and variety of Zoological materials is so great that we have distributed it as follows: ... and the *Pentacrinus*, *Ammodiscus* and Foraminifera by Dr. Carpenter..." It is interesting to note that Carpenter and Jeffries did not consider this to be a foraminifer but an "Actinozoon." Thus this is a homonymous usage of the name *Ammodiscus* for an actinozoan (anthozoan) and was not considered a reference to a foraminifer nor to *Ammodiscus* Reuss. *Ammodiscus lindahli* thus cannot be used as a type species for the foraminiferal genus *Ammodiscus*.

The next species cited in connection with *Ammodiscus* is *Ammodiscus infimus* (Strickland) Bornemann (1874, p. 725) (= *Orbis infimus* Strickland, 1846). As this is the first valid reference citing a species of *Ammodiscus* it automatically becomes the type species of *Ammodiscus*. Strickland's types are in London, the lectotype (designated by Barnard, 1952) (Cat. no. P 40870) and paratypes (Cat. no. P 40871) separated from the original type rock specimen (Cat. no. 32718) are in the British Museum (Natural History), and topotypes in the collections of the Geological Survey and Museum (no. 73204–5 and slides nos. 90171–78), also in London. These types were examined and redescribed by Barnard (1952, p. 905) and were shown to belong to *Spirillina* Ehrenberg, 1843, as they are hyaline, calcareous forms. As its type species is thus a *Spirillina* the genus *Ammodiscus* Reuss, 1862, is a junior synonym of *Spirillina* Ehrenberg, 1843, and therefore must be suppressed.

Actually, even if the species cited as type by Cushman (*Operculina incerta* d'Orbigny) were to be kept as type species by an appeal to the international Commission, the genus would still

have no standing. D'Orbigny's types of *Operculina incerta* were examined by the writers in Paris and found not to be an agglutinated form but a calcareous imperforate form and a typical *Cornuspira* Schultze, 1854. Three syntypes of d'Orbigny's species are preserved in the collections of the Muséum National d'Histoire Naturelle in Paris. That here figured (Figs. 1*a*, 1*b*) is hereby designated the lectotype of *Operculina incerta* and the remaining two specimens become paratypes. All are from the Recent of Cuba. All three specimens of *Operculina incerta* in the d'Orbigny collection are imperforate calcareous forms and thus not in the least similar to what has for many years been considered *Ammodiscus*. It is interesting to note that d'Orbigny's description of the species made no mention of it being arenaceous, as has been later assumed. He had commented only that its slight degree of transparence made it difficult to study the structure. Normally an arenaceous test would not be expected to show any transparence, which might also have suggested that d'Orbigny was not referring to an agglutinated form but to a porcellanous one.

This suppression of the generic name *Ammodiscus* as a synonym of *Spirillina* would seem to leave nameless those planispiral agglutinated forms commonly placed in *Ammodiscus*. Nevertheless, an examination of Terquem's types shows that the genus *Involutina*, as represented by its type species *I. silicea* Terquem, is an agglutinated form and does not have partial internal septa, but is completely undivided internally. The diagrammatic figures of Terquem interpreted as showing partial septa represent merely the slight undulations of the surface usually considered as growth wrinkles. Thus the species previously considered as *Ammodiscus* will fall in the genus *Involutina*, which therefore does not belong to the Silicinidae: This problem is further discussed under the generic emendation of *Involutina* which follows.

As the type species of *Ammodiscus*, *Orbis infimus* Strickland, has recently been well defined by Barnard, we have not redescribed the species here. However, the species *Operculina incerta* d'Orbigny, cited erroneously as type for *Ammodiscus* by Cushman, has never been accurately defined, and an emendation of this species follows, although it belongs with *Cornuspira* rather than with *Ammodiscus*.

Cornuspira incerta (d'Orbigny), emended

Figs. 1*a*, 1*b*

Operculina incerta d'Orbigny, 1839, *Foraminifères*. In: Ramon de la Sagra, Hist. Phys. Nat. île Cuba: 49.

Emended diagnosis.—Test free, discoidal, consisting of a globular proloculus and long undivided tubular planispiral second chamber forming about 12 coils, with succeeding whorls partially overlapping those preceding; wall calcareous, imperforate; aperture at the open end of the tube.

Greatest diameter of lectotype 1.36 mm, least diameter 1.13 mm, greatest thickness 0.25 mm.

Types and occurrence.—Three syntypes of d'Orbigny are preserved in the collections of the Muséum National d'Histoire Naturelle in Paris. That here figured is here designated as lectotype, the remaining two specimens becoming paratypes. All are from the Recent of Cuba.

Remarks.—As mentioned under the emendation of *Ammodiscus*, this species has been cited (although erroneously) as the type species of *Ammodiscus*. The types of the species show it to belong to *Cornuspira* Schultze, 1854.

Family TOLYPAMMINIDAE Cushman, 1929

Cushman first used the name Tolypammininae for a subfamily of the family Ammodiscidae Reuss, 1862. As *Ammodiscus* has been shown to be a junior synonym of *Spirillina* Ehrenberg, 1843, it is removed from the family previously called Ammodiscidae, and hence that family name must be removed with it. As subfamily and family names are considered of equal importance for purpose of priority, the next available name for this family is therefore the Tolypamminidae.

Subfamily INVOLUTININAE Cushman, 1940

The subfamily Involutininae will include those genera previously placed in the Ammodiscinae—namely the free forms which have a globular proloculus and long undivided tubular second chamber, either in a planispiral or trochoid coil, and cannot be used as a subfamily of the Silicinidae.

Genus **Involutina** Terquem, 1862

Original description.—Mém. Acad. Imp. Metz, ann. 42 (ser. 2, ann. 9), 1860–1861: 450. 1862.

Types species.—*Involutina silicea* Terquem, 1862. Monotypic.

Diagnosis.—Test free, discoidal, with proloculus followed by an undivided planispiral tubular chamber, which slightly overlaps preceding whorls at the lateral margins, occasional irregular surficial transverse constrictions possibly denoting stages of growth, but without internal septa; wall finely agglutinated, of sand grains with considerable cement; aperture at the open end of the tube.

Discussion.—As noted under the emendation

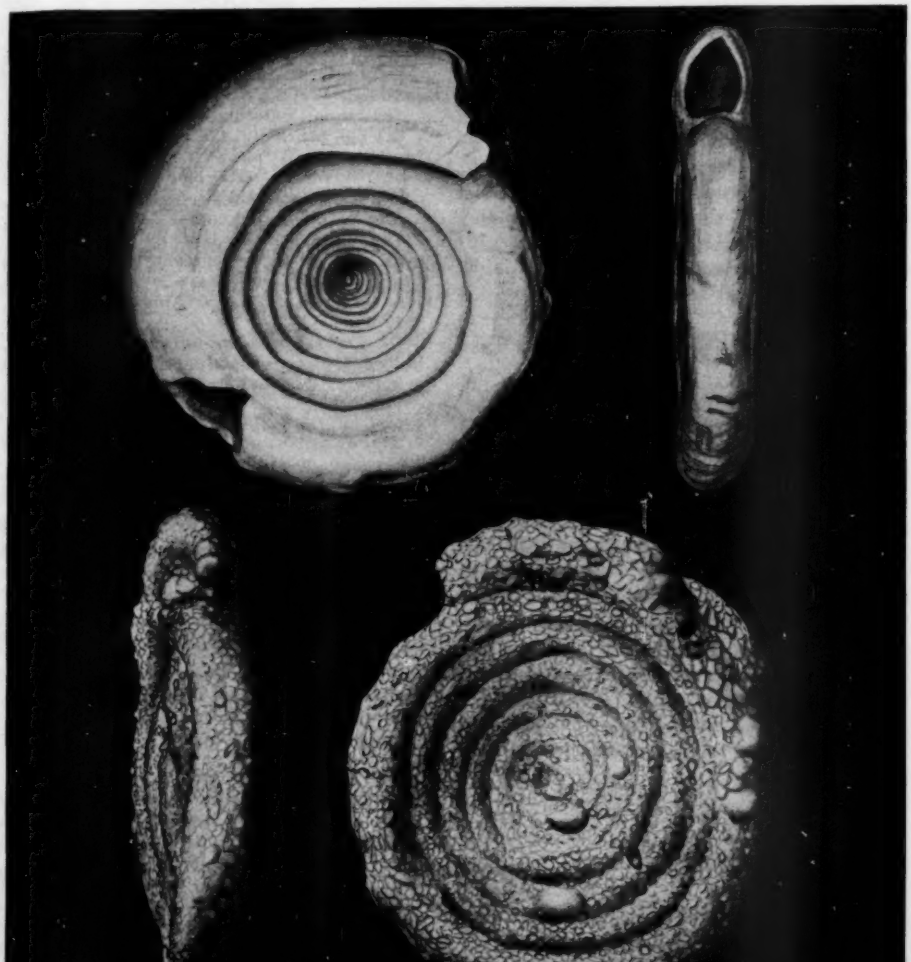

FIG. 1.—*Cornuspira incerta* (d'Orbigny), lectotype, Muséum National d'Histoire Naturelle, Paris, Recent of Cuba: 1*a*, Side view, showing planispiral calcareous test; 1*b*, edge view, showing aperture at open end of the tube. × 53. Camera-lucida drawings by Helen Tappan Loeblich.

FIG. 2.—*Involutina silicea* Terquem, lectotype, Muséum National d'Histoire Naturelle, Paris, Lias Moyen, St. Julien-les-Metz, France: 2*a*, Side view, showing nonseptate, planispiral agglutinated test; 2*b*, edge view. × 65. Camera-lucida drawings by Lawrence Isham, scientific illustrator, Smithsonian Institution.

of *Ammodiscus* the genus *Involutina* is not subdivided internally, and in fact represents the form previously referred to *Ammodiscus*. This is not a completely unlooked-for discovery, as Macfadyen (1941, p. 17) stated that specimens sent to Brady by Terquem and in the Brady collection at the British Museum (Natural History), London, and which are labelled *Involutina* (*Cornuspira*) *silicea* Terquem, Lias Moyen, Metz, were "... all of the form that I have identified as *Ammodiscus asper* (Terquem)." On this basis Macfadyen stated that *Involutina* was probably a synonym of *Ammodiscus*, subject to confirmation by the type species. The types also are planispiral, agglutinated, undivided forms and thus the generic name *Involutina* must be used for those species previously referred to *Ammodiscus*, as *Ammodiscus* itself is found to be synonymous with *Spirillina*.

Involutina silicea Terquem, emended
Figs. 2*a*, 2*b*

Involutina silicea Terquem, Mém. Acad. Imp. Metz, ann. 42 (ser. 2, ann. 9), 1860–1861: 450. 1862.

Emended diagnosis.—Test free, discoidal; proloculus followed by an undivided planispiral tubular chamber forming about seven or eight coils which are slightly overlapping at the lateral margins, crossed by occasional irregular surficial growth constrictions, but completely lacking any internal septa or subdivisions; wall finely agglutinated, composed of quartz grains embedded in a large amount of cement; aperture at the open end of the tube.

Greatest diameter of lectotype 1.18 mm, least diameter 0.95 mm, greatest thickness 0.23 mm.

Types and occurrence.—Lectotype (here designated) and paratypes in the Muséum National d'Histoire Naturelle, Paris. All are from the Lias Moyen, St. Julien-les-Metz, France.

Remarks.—This species is the type species of *Involutina* Terquem. The transverse growth wrinkles were interpreted by Terquem as septa. Actually they are not reflected on the interior of the shell. As the type species of *Ammodiscus* Reuss, 1862, has been shown to be a hyaline calcareous form, Reuss's genus is a synonym of *Spirillina*. As *Involutina* is shown to be an agglutinated non-septate planispiral form, the agglutinated species formerly included in *Ammodiscus* by later authors should correctly be placed in *Involutina*.

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BOTANY.—*Xyridaceae from Brazil.* LYMAN B. SMITH, Department of Botany, U. S. National Museum, and ROBERT J. DOWNS, Plant Industry Station, U. S. Department of Agriculture.

At the kind suggestion of Dr. F. Segadas Vianna, we have borrowed the material of Xyridaceae from the Museu Nacional in Rio de Janeiro (R) and studied it in comparison with the collections in the U. S. National Herbarium (US). Much of the material of the Museu Nacional has been determined by the most recent monographer of the family, the late Dr. G. O. A. Malme, so that our studies have been rewarding chiefly in the better understanding of old species. However, several new species have been brought to light as noted below.

Xyris (Nematopus) cipoensis Smith & Downs, sp. nov. FIG. 1, *a-f*

Caespitosa; radicibus gracilibus; foliis 15–29 cm longis, anguste cartilagineo-marginatis; vaginis anguste triangularibus, tertiam vel dimidiam partem folii occupantibus, ligula haud munitis, ad basin versus tuberculatis atro-castaneis et opacis; laminis ensiformi-linearibus, 3–4 mm latis, acutis vel acuminatis, utraque acie scabridulis, alibi sublaevibus, nervoso-striatis; scapo 40–60 cm alto, ad 2.5 mm diametro, leviter compresso, sublaeve; vagina basali 14–21 cm longa, in apiculum brevem acutum excurrente; spica globosa, 15–20 mm longa, glabra; bracteis exterioribus squarrosis vel recurvatis, angustissime triangularibus, longe acuminatis, 15–20 mm longis, ecarinatis, area dorsali carentibus, anguste pallido-marginatis, alibi atro-castaneis, opacis, tuberculatis, bracteis fertilibus eis exterioribus omnino similibus; sepalis lateralibus liberis, lineari-lanceolatis, acuminatis, 14 mm longis, ala carinali angusta, laxe serrata; petalis aureis, laminis obovatis, 10 mm longis; antheris anguste oblongis, quam filamentis subtriplo longioribus; staminodiis bibrachiatis, penicillatis; placentis basalibus.

Type in the U. S. National Herbarium, no. 2121733, collected in wet campo, Santa Luzia, Serra do Cipó, km 121 from Belo Horizonte, State of Minas Gerais, Brazil, July 6, 1936, by W. A. Archer and Mello Barreto (no. 4914).

The following agrees closely with the type in all observable details but shows no flowers in the axils of the bracts: Minas Gerais: Mun. Jaboticatubas: Serra do Cipó, 6 km north of Palacio, 19°10′ S., 43°35′ W., altitude 1,200 meters, April 29, 1952, *L. B. Smith et al. in Museu Nacional-Smithsonian* 6872 (R, US).

Xyris (Nematopus) melanopoda Smith & Downs, sp. nov. FIG. 1, *g-k*

Caespitosa, subcaulescens; rhizomate crasso, brevi, subverticali; radicibus tenuibus; foliis manifeste distichis, ensiformi-linearibus, ad 17 cm longis, 3–4.5 mm latis, sursum angustatis, apice acutis, in sicco nervoso-striatis, utroque latere laevibus glaberrimisque, aciebus subtilissime ciliato-scabridulis, nervis submarginalibus paulo incrassatis; vaginis ca. tertiam partem folii occupantibus, eciliatis, opacis, superne lamina haud latiorem, basi valde dilalatis et aterrimo-castaneis, ligula distincta, ad 4 mm longa, acuta; scapis terminalibus vel lateralibus, spiraliter tortis, bicostatis, 25–40 cm altis, vix ultra 1 mm latis, glabris, obscure nervatis, vagina scaporum quam foliis breviore, in apiculum foliaceum brevem excurrente, brunnea; spica multiflora, obovoidea vel conica, 9–12 mm longa; bracteis coriaceis, integerrimis, glabris, ferrugineis, opacis, inferioribus (sterilibus) satis numerosis, ovatis, obtusis, 3 mm longis, plus minusve carinatis, area dorsali cinereo-viridi anguste lanceolata notatis, intermediis latioribus, sepala superantibus, ecarinatis, area dorsali ovata notatis; sepalis lateralibus liberis, navicularibus, acutis, 4.5 mm longis, glabris, ala carinali angusta, integerrima; limbo petalorum obovato, ex sicco 4 mm longo; antheris oblongis, ca. 2 mm longis; staminodiis penicillatis; placentis basalibus.

Type in the U. S. National Herbarium, no. 1705665, collected at Serra do Cipó, State of Minas Gerais, Brazil, altitude 1,800 meters, August 5, 1936, by W. A. Archer (no. 3680).

The nearest relative to our species appears to be *X. bialata* Malme, but in addition to the winged scape from which it derives its name this differs in its lustrous leaf-bases, straight scape, and obtuse ciliate-serrulate sepals.

Xyris (Nematopus) mello-barretoi Smith & Downs, sp. nov. FIG. 1, *l-p*

Caespitosa, acaulis; radicibus tenuissimis; foliis ensiformi-linearibus, ad 15 cm longis, 3.5 mm latis, apice acutis apiculatisque, utroque latere rubentibus et minutissime tuberculatis vel aliquis

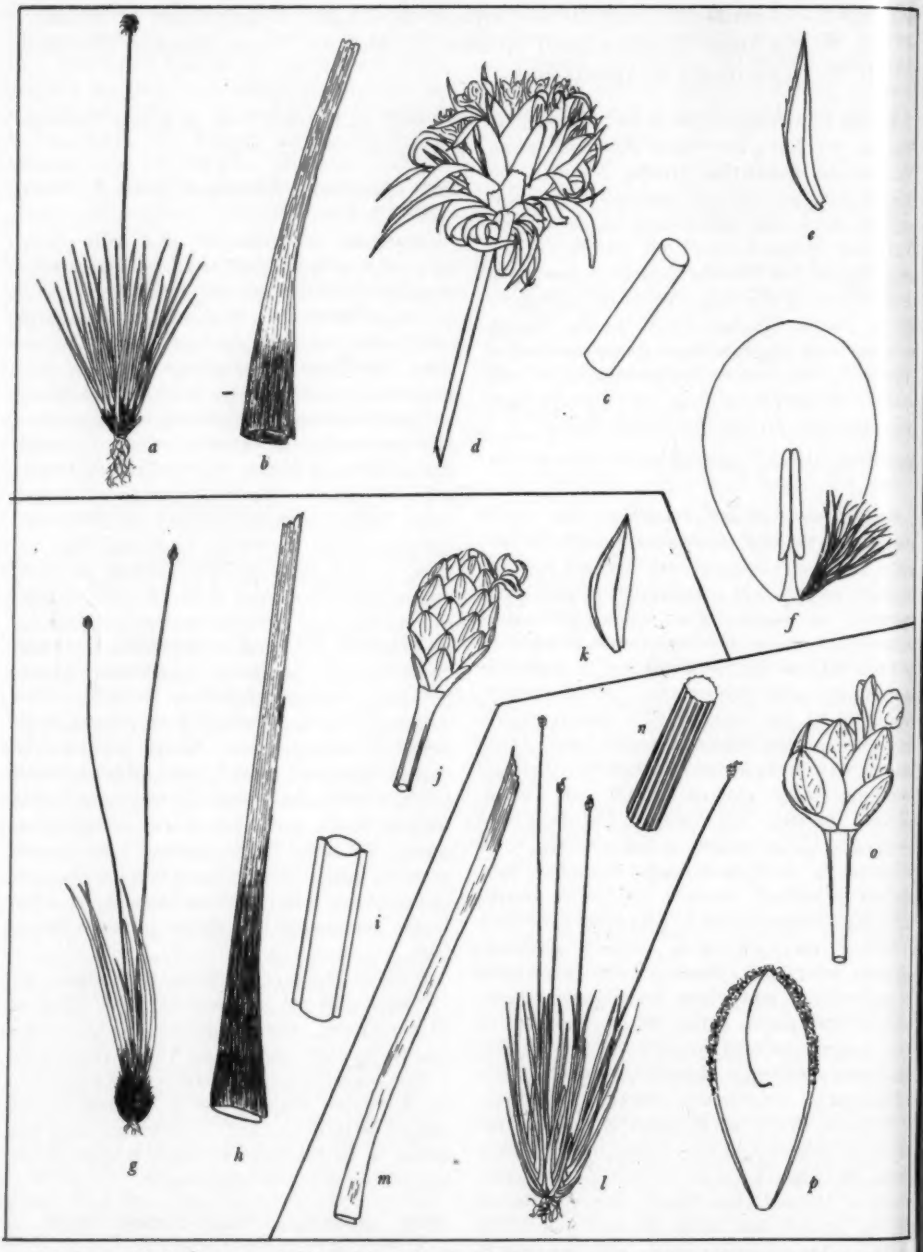

FIG. 1.—*a*, *Xyris cipoensis*, habit × 1/10; *b*, base of leaf × 1; *c*, section of scape × 5; *d*, inflorescence × 1; *e*, posterior sepal × 2; *f*, petal, stamen, and staminode × 5. *g*, *Xyris melanopoda*, habit × 1/5; *h*, base of leaf × 1; *i*, section of scape × 5; *j*, inflorescence × 2; *k*, posterior sepal × 5. *l*, *Xyris mello-barretoi*, habit × 1/5; *m*, base of leaf × 1; *n*, section of scape × 5; *o*, inflorescence × 2; *p*, posterior sepals × 5.

laevibus, glaberrimis, aciebus viridibus laevissimisque, vaginis dimidiam partem folii occupantibus, eciliatis, opacis, basi dilatatis et stramineis, ligula minima; scapis terminalibus, rectis, ad 34 cm altis, teretibus, ca. 1 mm diametro, pluricostatis, glabris laevibusque, vagina scaporum folia subaequante, in apiculum foliaceum brevem excurrente; spica subpauciflora, late ellipsoidea vel globosa, 7–9 mm longa; bracteis fere integris sed ex sicco faciliter fractis, glabris, dilute ferrugineis, opacis, ecarinatis, late rotundatis, infimis late ellipticis, 4–5 mm longis, area dorsali anguste elliptica, intermediis obovatis, sepala superantibus, area dorsali brevi, late ovata; sepalis lateralibus postice in parte dimidia connatis, spathulatis, obtusis, 7 mm longis, ala carinali angusta, inferne nuda, superne pilis fulvis crebris villosa; petalis aureis; staminodiis penicillatis; placentis basalibus.

Type in the Museu Nacional, Rio de Janeiro, no. 35284, collected in swamp, Guinda, Municipio of Diamantina, State of Minas Gerais, Brazil, November 5, 1937, by Mello Barreto (no. 9486).

Its tuberculate leaves and connate villous sepals relate *Xyris mello-barretoi* to *X. trachyphylla* Mart. and *X. consanguinea* Kunth, but its pale leaf-sheaths and pluricostate scapes easily distinguish it. Also the dorsal area in *X. mello-barretoi* is even with the rest of the bract, not impressed, and on the upper bracts it is relatively short and broad.

Abolboda pulchella Humb. & Bonpl. Plant. Aequin. **2**: 110, pl. 114. 1813.
Xyris vaginata Spreng. Syst. Veg. **1**: 183. 1825.
Abolboda brasiliensis Kunth, Enum. Plant. **4**: 26. 1843.
Abolboda vaginata (Spreng.) Alb. Nilss. K. Sv. Vet. Akad. Handl. **24**, no. 14: 63. 1892.
Abolboda longifolia Malme, Bihang till. K. Sv. Vet. Akad. Handl. **22**, Afd. 3, no. 2: 20, pl. 2. 1896.
Abolboda gracilis Huber, Bol. Mus. Goeldi **5**: 323. 1909.

In his synopsis of *Abolboda* in 1924 (Arkiv Bot. **19**, no. 13: 5), Malme made all the above reductions except *A. vaginata*. This he separated on the length of the leaves relative to the basal scape-bract and on the position of the appendage on the style.

In 1935 Suessenguth and Beyerle (Bot. Jahrb. **67**: 132) published a detailed study of the morphology of *Abolboda* with a synopsis of the species. They also divided *A. vaginata* from *A. pulchella*, but reversed Malme's testimony on the position and shape of the style-appendages and used other characters than the leaves. Neither they nor Malme noted the complete lack of any style-appendage in the original illustration of *A. pulchella*.

An examination of the material listed below has led us to the conclusion that it is impossible to classify the collections into two distinct species on the basis of any previous system nor can we find a new one. Characters previously used broke down within a single collection, and the much emphasized character of the style-appendage proved completely unreliable, varying widely with each flower examined. We are forced to the conclusion that previous authors were able to examine but a single flower per species.

BRAZIL: Rio Branco: Vera Cruz, *Luetzelburg* 20663 (R). Lagoa de Moça, *Luetzelburg* 20702 (R). Serra do Murupú, *Luetzelburg* 20772 (R). Pará: Ilha do Marajó, Rio Camará, Retiro Pau-Grande, *Rubens Lima* 42, 91 (US). Minas Gerais: Mun. Diamantina: Bom Successo, *Mello Barreto* 9659 (R). Goiás: Near Morro Redondo, *Glaziou* 22234 (US). Mato Grosso: *H. Smith* 171 in part (R). Aricá, near Cuiabá, *Malme* II—3262 (US). Between Cabral and Serra da Chapada, *Malme* II—3262-a (R). Tapirapoan, *Hoehne in Com. Rondon* 1471 (R). Conceição de Aricá, *Hoehne in Com. Rondon* 3603 (R). Cataqui-Iamain, *J. G. Kuhlmann in Com. Rondon* 1627 (R).

VENEZUELA: Anzoátegui: El Tigrito, *H. Pittier* 15080 (US). Bolívar: Gran Sabana, between Kun and waterfall at Ruémerú (tributary of Río Kukenán), south of Mount Roraima, *Steyermark* 59178 (US). Río Karuai, between Santa Teresita de Kavanayén and base of Ptari-tepuí, *Steyermark* 60301 (US). Kavanayén, Guayana Venezolana, *Lasser* 1814 (US). Amazonas: Puerto Ayacucho, *L. Williams* 15944 (US).

Abolboda poarchon Seubert in Mart. Fl. Bras. **3**: pt. 1: 223. 1855.
Abolboda chapadensis Hoehne, Comm. Linh. Telegr. Estrat. Matto Grosso, Annexo 5, Bot. pt. 5: 11, pl. 80, fig. 2. 1915.

In *Abolboda poarchon* we have observed the same variation of the style-appendage as in *A. pulchella*. Consequently we feel that Suessenguth and Beyerle were unjustified in restoring *A. chapadensis* after its reduction by Malme. It is noteworthy that Hoehne (Ind. Bibl. e Num. Plant. Col. Com. Rondon 144. 1951) later concurred with the reduction of his own species.

BRAZIL: Pará: Campo Piranema, Rio Mojú, *Goeldi* (US). Minas Gerais: Mun. Diamantina: Boa Vista—Extracção, *Mello Barreto* 9657 (R). Goiás: Serra dos Pireneos, *Ule* 227 (R). Mun. Corumbá: Pirineus, *Macedo* 3700 (US). Mato Grosso: Between Buriti and Santa Ana de Chapada, *Malme* II—2354 (US). Chapada, headwaters of Rio Taquara-ussu, *Hoehne in Com. Rondon* 3597 -9 (R, type of *Abolboda chapadensis* Hoehne).

ENTOMOLOGY.—*New Cantharidae (Coleoptera) from the collection of the United States National Museum.*[1] W. WITTMER. (Communicated by Oscar L. Cartwright.)

The following descriptions are based on material submitted to the author for identification by the United States National Museum, Washington, D. C. All holotypes are in the collection of that museum.

Discodon humeropictum, n. sp.

Black-brown, only one oblong extremely narrow, yellow spot on the humeral calli, touching the base and frequently also extending to the apices of the elytra. Mandibles red-brown. Head with the eyes nearly as wide as the pronotum, rather densely, finely punctate and pubescent. Antennae projecting a little beyond the base of the hind coxae, second segment hardly longer than wide, the third a trifle shorter than the fourth, seventh to tenth with a short distinct longitudinal groove. Pronotum somewhat wider than long, the sides weakly narrowed anteriorly, lateral notch indicated by a weak impression a little before the middle, median line in the basal half distinct, punctuation much finer and less distinct than on the head. Elytra with a rugose effect and with traces of two longitudinal costae. Length: 6.5–7.5 mm.

Type.—Holotype male, U.S.N.M. 62348. Allotype in author's collection.

Type locality.—Huanuco, Peru. Specimens collected August 31, 1928, by A. J. Barton, no. 239.28.

This new species belongs to the group of very few species with unicolorously black pronotum; it is somewhat reminiscent of the darkest forms of *D. obscuricolle* Wittmer, whose pronotum, however, is always somewhat pale, at least in the basal angles. The antennae differ: in *humeropictum* segments 7 to 10 are indented with a longitudinal groove; in *obscuricolle* segments 4 to 10 are thus marked.

Discodon arnetti, n. sp.

MALE. Deep black, pronotum yellow with a triangular black-brown spot whose apex is turned cephalad not quite reaching the anterior margin; elytra with a faint bluish shimmer. Head with the eyes much narrower than the pronotum, front rather flat, with a weak longitudinal callus between the eyes toward the clypeus, surface rather smooth, rather densely provided with hair punctures toward the anterior margin of the pronotum. Antennae long and slender, second segment half as long as the third, the third a trifle shorter than the fourth, the seventh to the eleventh with a distinct longitudinal groove on the upper side. Pronotum wider than long, sides barely round and slightly narrowed anteriorly; lateral margins barely impressed in the middle; anterior angles more strongly rounded than the basal angles; disk rather flat, slightly impressed in the middle, before the base; surface smooth, shining; pubescence sparse. Elytra rugose, with a slightly granular effect, with traces of a longitudinal costa. (Male genitalia, see Fig. 1.) Length: 11–12 mm.

Type.—Holotype male, U.S.N.M. 62349.

Type locality.—Lucma, Peru. Collected at 7,000 feet, Aug. 25, 1911, by Yale Peruvian Expedition.

The species is to be readily recognized by the sides of the pronotum, which lack the usual short emargination. It is named in honor of the well-known specialist in Oedemeridae, Dr. Ross H. Arnett, Jr.

Discodon chapini, n. sp.

MALE. Yellow, head, except the cheeks, and elytra, black, scutellum slightly darkened. Head with the eyes hardly narrower than the pronotum, front slightly convex, surface nearly smooth, somewhat more strongly pubescent toward the anterior margin of the pronotum than between the eyes. Antennae broken off at the 2nd segment. Pronotum somewhat wider than long, sides distinctly narrowed anteriorly; lateral margins with a short distinct emargination in the middle; anterior angles strongly rounded, almost merging with the anterior margin; basal angles nearly rectangular; disk slightly convex, median line absent; surface smooth. Elytra with a granular effect with traces of 2 longitudinal costae. (Male genitalia, see Fig. 2.) Length: 9 mm.

Type.—Holotype male, U.S.N.M. 62350.

Type locality.—"Piches & Perene Vs., Peru. Collected between 2000 and 3000 feet, by Geographical Society of Lima.

[1] 15th contribution to the knowledge of the Neotropical Malacodermata.

FIGS. 1–6.—Male genitalia of: 1, *Discodon arnetti*, n. sp., male; 2, *D. chapini*, n. sp., male; 3, *D. horni* Pic, male; 4, *D. huadquinaense*, n. sp., male; 5, *D. chacoense* Pic ♀, male; 6, *D. peruvianum*, n. sp., male. FIG. 7.—Half of the pronotum of *Silis arnetti*, n. sp., male. FIG. 8.—Apex of abdomen, ventrally, of *Malthinus venezuelensis*, n. sp., male. FIG. 9.—Last sternite of *Maltypus minutus*, n. sp., male.

This species is named in honor of Dr. Edward A. Chapin, retired, former chief, Division of Insects, United States National Museum. It is very closely related to *D. horni* Pic, but is to be readily recognized by the all yellow legs. The male genitalia are very different; see also Fig. 3 (of *D. horni*).

Discodon huadquinaense, n. sp.

MALE. Yellow-orange, eyes, antennae from the middle of the second segment on, and elytra, black-brown. Head with the eyes narrower than the pronotum, a weak protuberance between the eyes, surface rather densely pubescent, with distinct hair-punctures. Antennae long, reaching beyond the coxae of the hind legs, second segment a little more than half as long as the third, the third a trifle shorter than the fourth, the eighth to the eleventh with a distinct longitudinal groove, which in the eleventh is shorter than in the preceding segments. Pronotum wider than long, anteriorly narrower than at the base, sides distinctly emarginate a little before the middle, from the emargination to the base the sides weakly lobelike, strongly rounded, the anterior part of the sides straighter, median line absent; surface not very strongly pubescent, hair punctures hardly perceptible. Elytra with a rugose effect, with traces of 2 longitudinal costae. (Male genitalia, see Fig. 4.) Length: 11 mm.

Type.—Holotype male, U.S.N.M. 62351.

Type locality.—Huadquina, Peru. Collected at 5,000 feet, July 30, 1911, Yale Peruvian Expedition.

This species has yellow legs, like the foregoing, is related to *D. chaparense* Wittmer which has a similarly shaped pronotum, with the difference that the legs of *D. chaparense* are unicolorously black, by which the new species may be readily separated.

Discodon chacoense Pic ?

A specimen from Lucma, Peru, 7,000 feet, August 25, 1951, collected by the Yale Peruvian Expedition, which lies before me, agrees with Pic's brief description (l'Echange hors-texte **42:** 27, 1926) down to the coloring of the elytra, which, in the present species, are slightly paler on the basal third at the suture. For better recognition of the species hereafter, which is perhaps different from *D. chacoense* and new, I am including a drawing of the male genitalia (Fig. 5).

Discodon peruvianum, n. sp.

MALE. Head black, only the cheeks a little paler, antennae and ventral aspect dark brown, scutellum darkened, pronotum and legs yellow, dorsal aspect of the tibiae at the base and the tarsi brown, elytra yellow, base and apex broadly dark-brown, the two dark bands together wider than the yellow middle. Head with the eyes as wide as the pronotum, front shallowly impressed between the eyes, pubescence not very strong, with fine scattered hair punctures. Antennae rather long, segments weakly flattened, the third to the seventh somewhat wider toward the apex than at the base, the remaining segments nearly parallel, the ninth to the eleventh with a fine longitudinal groove. Pronotum somewhat wider than long, sides nearly parallel, weakly notched shortly before the middle, beside the notch the sides are weakly thickened forward and somewhat raised, median line absent, surface nearly smooth, somewhat pubescent. Elytra with a granular effect, with traces of two longitudinal costae. (Male genitalia, see Fig. 6.) Length: 9 mm.

Type.—Holotype male, U.S.N.M. 62352.

Type locality.—"Piches & Perene Vs.," Peru. Collected between 2,000 and 3,000 feet by the Geographical Society of Lima.

Related to *D. brevebasale* Pic, this new species is larger and has the dark coloring at base and apex of the elytra more broadly extended than *brevebasale*.

Polemius unisulcatus, n. sp.

MALE. Yellow-brown, head and elytra dark-brown, outermost lateral margin faintly paler in the basal half. Head with the eyes as wide as the pronotum, front between the eyes nearly completely flat, hardly impressed, surface smooth. Antennae rather long, segments nearly parallel, scarcely wider at the distal end than at the base, second segment a little longer than wide, the third as long as the fourth, the fifth a trifle longer than the fourth, the eighth the longest, a little wider than the remaining segments, dorsally with a rather wide deep longitudinal groove which reaches neither the base nor the distal end, somewhat closer to the base than to the distal end, the ninth to the eleventh longer than the seventh, the eleventh even still a little longer than the eighth, all three narrower than the foregoing. Pronotum wider than long, slightly

narrowed forwards, lateral margin weakly thickened in the middle, slightly raised, anterior and basal angles rounded, disk rather flat, middle line on the basal half weakly indicated, surface smooth. Elytra elongate, with a rugose effect. The one front claw with a wide lobe, one middle and hind claw split, one part distinctly shorter than the other and only weakly thickened.

FEMALE. The single specimen before me is colored somewhat darker than the male, antennae brown, the last three segments yellow, base of the middle and hind tibiae and their tarsi a little darkened. Eighth antennal segment simple, without a longitudinal impression, only a little thicker than the ninth. Length: 6.5 mm.

Type.—Holotype male, U.S.N.M. 62353. Allotype in author's collection.

Type locality.—La Merced, Chanchamayo, Peru. Collected at 1,000–1,200 m, December 1908 and February 1909, by Carl O. Schunke.

The marking on the eighth antennal segment well characterizes the species; it belongs to the species of *Polemius* whose antennal segments are not widened toward the distal end.

Silis arnetti, n. sp.

MALE. Head black, yellow-orange before the bases of the antennae, these dark with the first three or four segments paler, pronotum and scutellum yellow-orange, the latter lightly darkened toward the apex. Elytra black, sides narrowly rather white-edged, legs yellow, the knee faintly darkened, abdomen yellow, the last 3 or 4 segments dark. Head with the eyes a little narrower than the pronotum, front between the eyes flattened, surface smooth and shining, with fine pubescence like powder. Antennae not very long, first segment only a little thickened toward the distal end, the second only a little longer than wide, the third somewhat longer than the fourth, the fourth and succeeding ones again becoming gradually shorter. Pronotum (Fig. 7) wider than long, rather deeply emarginate before the basal angles, the basal lamella somewhat arcuate, emarginated, and running out into a point that is curved anteriorly, lateral margins thickened before the emargination, rather strongly raised, disk slightly arcuate, surface nearly all smooth, shining and, like the head, with powderlike pubescence. Elytra a little widened posteriorly, with confused rugose punctation.

FEMALE. Coloring as in the male, pronotum simple, without emargination at the basal angles, lateral margins somewhat thickened and raised in the middle. Length: 3.5–4 mm.

Type.—Holotype male, U.S.N.M. 62354. Allotype in the collection of the United States National Museum, Washington; 2 female paratypes, Port of Spain, June 11–13, collected by August Busck, one in U.S.N.M., one in the author's collection.

Type locality.—St. Augustine, Trinidad, British West Indies. Collected on *Cordia*, June 14, 1944, by A. M. Adamson, no. 4166, I.C.T.A. 11813.

Related to *S. barticana* Pic, antennae slenderer, pronotum differently shaped.

Malthinus venezuelensis, n. sp.

MALE. Black, only the bases of the antennae, the clypeus, mouth parts, trochanters, and femora are lightened to whitish gray. Head with the eyes considerably wider than the pronotum, still a little wider than the elytra at the humeral calli, front slightly arcuate, surface nearly smooth. Antennae as long as the whole body, segments from the second on widened toward the distal end, from the sixth on the widening again abruptly decreases and the following segments are parallel, the second segment as long as the third, the fourth only a little longer than the third, the fifth and following segments about equal in length to each other, still a little longer than the fourth. Pronotum nearly twice as wide as long, sides parallel, median line distinct, disk slightly arcuate, surface nearly smooth, shining, with isolated hair punctures. Elytra greatly abbreviated, reaching the coxae of the hind legs, with a rugose effect. The last abdominal segment, ventrally; see Fig. 8. Length: about 3 mm.

Type.—Holotype male, U.S.N.M. 62355.

Type locality.—Tacarigua, Venezuela. Type collected March 1, 1949, by M. Villegas, no. 183931.

This species may be placed near *M. diversicornis* Champion, to which it is closely related. The new species is larger and the antennae are longer.

Maltypus minutus, n. sp.

MALE. Black-brown, head yellow-orange, tempora faintly darkened, the two basal segment of the antennae and the anterior margin of the pronotum in the middle, a little paler. Tibiae brown, femora somewhat lighter. Head with the eyes wider than the pronotum, front slightly

convex, smooth. Antennae not quite as long as the body, segments only a little thicker at the distal end than at the base, second segment as long as the third, the fourth longer than the third, the fifth still longer than the fourth. Pronotum nearly twice as wide as long, sides nearly parallel, median line indicated, surface nearly smooth. Elytra not reaching the coxae of the hind legs, with a rugose effect. The last sternite (Fig. 9) oblong-oval with a rather deeply and broadly emarginated distal end, in the normal condition, covered more than halfway by the next to the last sternite. The punctate field in the basal half is much less strongly chitinized than the rest and is semitransparent. Length: 2.5 mm.

Type.—Holotype male, U.S.N.M. 62356.

Type locality.—Rio de Janeiro, Brazil. Specimen collected on January 3, 1920, by E. G. Holt.

Apparently this species must be placed in the vicinity of *M. brasiliensis* (Pic) (described as *Malthodes* but very probably belonging to *Maltypus*). *M. brasiliensis* has yellow pronotum and ventral aspect, which parts are dark-colored in the new species.

Maronius centromaculatus, n. sp.

MALE. Black-brown, bases of the antennae, the cheeks and frequently also the whole anterior part in front of the antennal bases, the apices of the elytra and the abdomen except the last segment, yellow. Pronotum yellow with a large, nearly rectangular, brown spot which is often somewhat narrowed toward the base and touches neither the basal nor the anterior margin. Front legs frequently somewhat paler. Head with the eyes as wide as the pronotum, front nearly flat, surface nearly smooth. Antennae not very long, the third segment not quite twice as long as the second, the fourth the longest, somewhat longer than the third, the fifth only a little shorter than the third. Pronotum somewhat wider than long, sides nearly parallel, weakly sinuate toward the middle, surface weakly transversely impressed, nearly smooth, pubescence fine. Elytra hardly reaching beyond the coxae of the hind legs, each apex rounded off, an oblique fold on either side beginning under the humerus, running posteriorly toward the middle of the apex, becoming extinct before the apex, surface with an irregularly finely rugose effect. Length: 4–4.5 mm.

Type.—Holotype male, U.S.N.M. 62357. Allotype in the collection of the United States National Museum, paratype in author's collection.

Type locality.—San Salvador de Bahia, Brazil. The specimens were collected on May 28, 1915, by P. G. Russell.

Related to *M. limbatus* Pic which is similarly colored but readily separated therefrom by the proportions of length of the antennal segments, the coloring and formation of the elytra. In *limbatus* the fourth antennal segment is nearly twice as long as the third, the yellow coloring of the apices of the elytra shows up on the sides as a narrow border to beneath the humeral calli and the fold on the elytra is hardly indicated. In *centromaculatus* the fourth antennal segment is only a little longer than the third, the yellow coloring on the elytra is restricted to the apices, and the fold on the elytra is strongly developed.

ZOOLOGY.—*Two new subterranean shrimps (Decapoda: Caridea) from Florida and the West Indies, with a revised key to the American species.* FENNER A. CHACE, JR., U. S. National Museum.

Special thanks for the material and notes on which the following descriptions are based are due to the collectors: Dr. N. T. Mattox, of the University of Southern California; Capt. Merle L. Kuns, of the U. S. Air Force; and Robert B. Cumming, of the University of Florida.

The discovery of two additional shrimps from American subterranean waters and several recent nomenclatural changes (Holthuis, 1947, 1949, and 1950) have made the last published synopsis of these species (Chace, 1943) inadequate. A revised key is therefore offered below.

Typhlatya monae, n. sp.

Fig. 1

Holotype.—Female; Mona Island, Puerto Rico; from well 30 feet deep at "El Molino," about 1 mile southeast of NYA camp at Sardinera; October 11, 1953; collected by Merle L. Kuns; U. S. Nat. Mus. no. 96325.

Paratypes.—Four females; same locality as

holotype. Three females; old concrete water catchment basin on high plateau of Mona Island; January 1, 1951; collected by N. T. Mattox.

Description.—Carapace smooth and unarmed. Rostrum (Fig. 1*a–b*) short and triangular, falling far short of the tips of the eyes.

Abdomen smoothly rounded; margins of all pleura rounded, not angulate. Telson (Fig. 1*c*) about two and one half times as long as wide and armed typically with two pairs of dorsal spines and four pairs of terminal ones; a median pair of short setae is set between the two sets of terminal spines.

Eyes rounded triangular in dorsal view (Fig. 1*b*), with a small pigment spot on anterolateral margin.

Antennular peduncle (Fig. 1*a–b*) with a sharp stylocerite which falls slightly short of the end of the segment. Flagella subequal, slightly longer than carapace.

Antennal scale (Fig. 1*b*) extending beyond antennular peduncle; outer spine minute. Antennal flagellum nearly twice as long as antennular flagella.

The mouth parts are shown in Figs. 1*d–i*. Third maxilliped (Fig. 1*i*) reaching beyond antennal peduncle by nearly entire length of terminal segment.

The first, third, fourth, and fifth legs are shown in Figs. 1*j–m*. The second pair of legs was lacking in all specimens available. First four legs with well-developed exopods; that on fifth minute.

Gill series consists of five pairs of pleurobranchiae, one to each pair of legs, a pair of arthrobranchiae on third maxillipeds, and well-developed epipods on all but last pair of legs.

Size.—The holotype has a carapace length of 3.8 mm from the posterior margin of the orbit to the hind margin of the carapace. The carapace lengths of the female paratypes vary from 3.8 to 4.5 mm.

Biology.—The presence of this shrimp in a partially covered concrete water catchment basin is difficult to account for. This basin apparently has no connection with any subterranean water system; in fact, no underground passages are known in the high central mesa of Mona Island, although there are extensive ones through the low coastal plateau. At the time this collection was made, two specimens of a species of the *Olfersii* group of the large fresh-water shrimp *Macrobrachium* were found in the same tank; specific identification of these specimens was not possible because both lacked the large second chelae. A careful search of this locality in 1953 by Merle L. Kuns failed to reveal specimens of either of these shrimps.

Remarks.—*Typhlatya monae* closely resembles *T. garciai* Chace from a cave at Banes, Oriente Province, Cuba. It differs from that species in the nearly complete suppression of the exopod on the fifth leg, the broader telson, and slight differences in the form of the mouth parts. In the reduction of the last thoracic exopod, *T. monae* agrees with *T. pearsei* Creaser from caves in Yucatán, but in all other respects it seems more closely allied to *T. garciai*.

Palaemonetes (Palaemonetes) cummingi, n. sp.
Fig. 2

Holotype.—Female; Squirrel Chimney, Alachua County, Fla.; July 11, 1953; collected by Robert B. Cumming; U. S. Nat. Mus. no. 95795.

Description.—Rostrum (Fig. 2*a*) reaching about to end of antennular penducle, armed dorsally with six nearly equidistant teeth, the posterior one set behind level of orbital margin, and ventrally with three teeth. Carapace with a broad hump behind middle of dorsal margin. Integument firm. Antennal spine small but sharp and distinct. Branchiostegal spine similar in size to antennal, placed just below distinct branchiostegal groove, and reaching well beyond anterior margin of carapace.

Abdomen normal. All pleura rounded, that of fifth somite narrowed posteriorly but not acute. Sixth somite as long as telson exclusive of terminal spines. Telson (Fig. 2*c*) armed with an asymmetrically disposed pair of dorsal spines placed well behind the middle. Tip of telson (Fig. 2*d*) terminating in a sharp point and apparently armed with three pairs of spines and a median pair of plumose setae; the outer pair of spines obviously represents the posterior dorsal pair which has moved distally so far as to seem to form part of the terminal series.

Eyes (Fig. 2*a–b*) unpigmented, but the small, hemispherical cornea is distinguished from the much broader stalk.

Antennular peduncle (Fig. 2*b*) with a small, sharp stylocerite. Anterolateral spine of basal segment reaching barely beyond convex anterior margin of segment. Upper antennular flagellum four times as long as carapace, its two rami fused for about 16 joints; free portion of outer ramus

consisting of three or four joints and less than one third as long as fused portion. Lower antennular flagellum about three times as long as carapace.

Antennal scale (fig. 2*b*) about two and one half times as long as broad. Outer margin nearly straight. Distal tooth falling far short of end of blade. Antennal flagellum more than five times as long as carapace.

The mouth parts are shown in Figs. 2*f–k*. Third maxilliped (Fig. 2*k*) reaching to end of antennal peduncle.

First leg (Fig. 2*l*) reaching beyond antennal scale by about the length of the fingers. Fingers nearly half again as long as palm; cutting edges entire and closing throughout their lengths. Palm distinctly longer than high and bearing a row of stout curved setae on proximal half of outer lower margin. Carpus 1.8 times as long as chela and bearing a V-shaped brush of setae near distal end of lower margin. Merus 0.9 times as long as carpus, ischium half as long as merus. Second leg (Fig. 2*m*) longer than first, reaching beyond antennal scale by nearly entire length of chela. Fingers slightly shorter than palm; cutting edges entire and meeting throughout their lengths, except near base of fingers where a concavity in cutting edge of fixed finger leaves a narrow gap. Carpus a little more than one and one fourth times as long as chela. Merus about three fourths as long as carpus, ischium slightly longer than merus. Third leg (Fig. 2*n*) reaching beyond antennal scale by about one half of

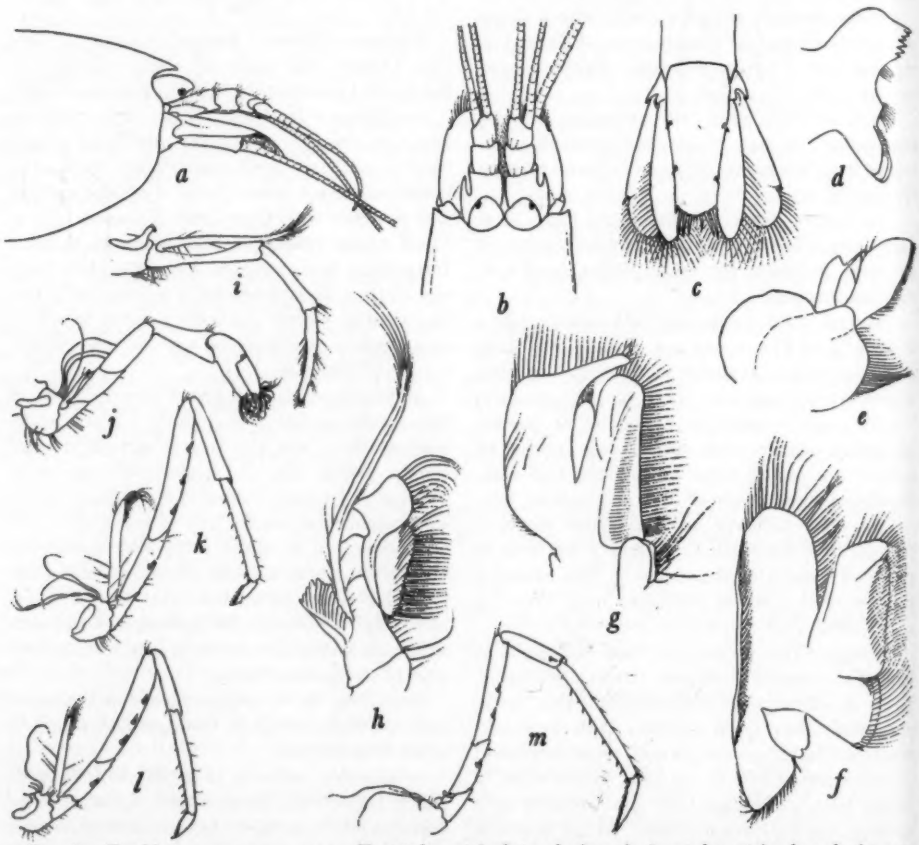

FIG. 1.—*Typhlatya monae*, n. sp.: *a*, Frontal part in lateral view; *b*, frontal part in dorsal view; *c*, telson and uropods in dorsal view; *d*, right mandible; *e*, right first maxilla; *f*, right second maxilla; *g*, right first maxilliped; *h*, right second maxilliped; *i*, right third maxilliped; *j*, right first leg; *k*, right third leg; *l*, right fourth leg; *m*, right fifth leg. *a–i*, *k–m*, female holotype; *j*, female paratype. *a–c*, *i–m*, × 12.5; *d*, × 36.6; *e–h*, × 27.3.

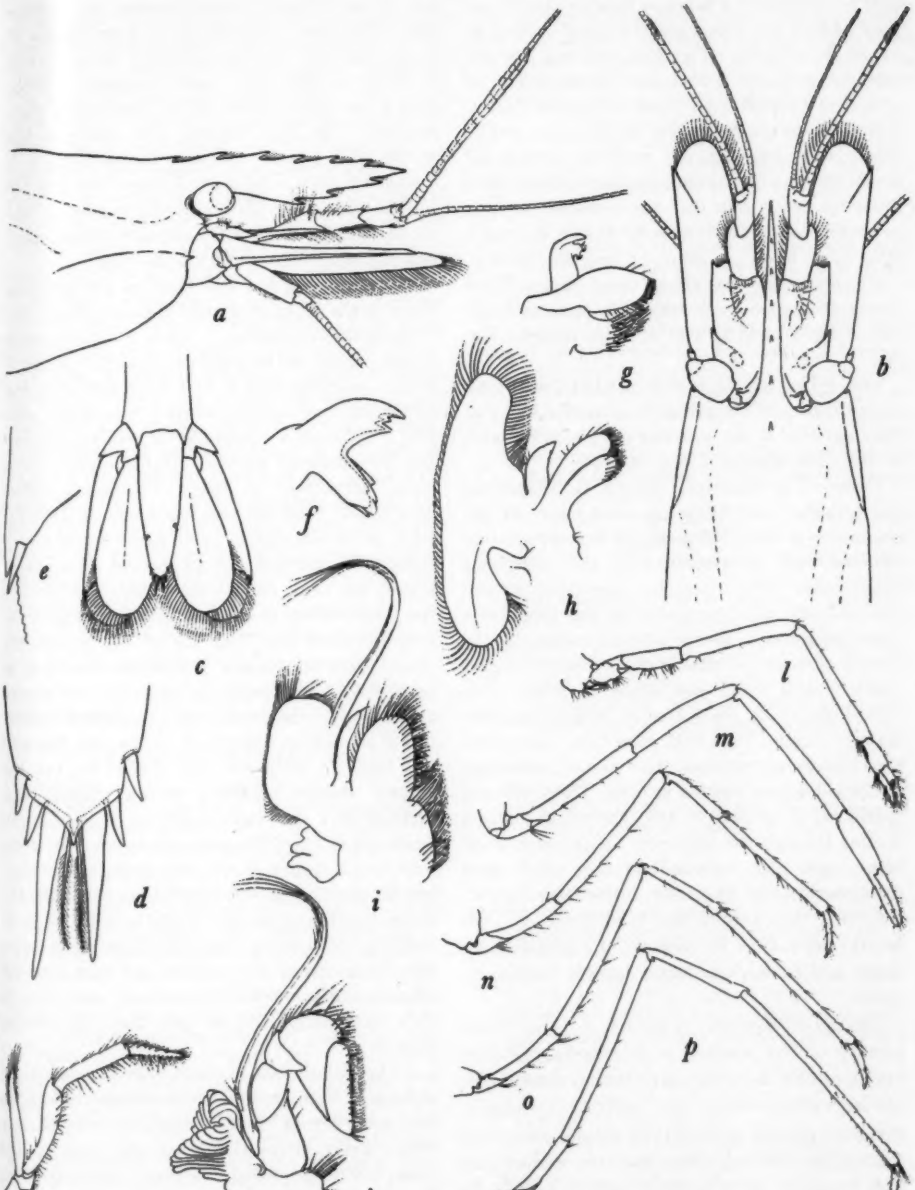

FIG. 2.—*Palaemonetes* (*Palaemonetes*) *cummingi*, n. sp., female holotype: *a*, Frontal part in lateral view; *b*, frontal part in dorsal view; *c*, telson and uropods in dorsal view; *d*, tip of telson in dorsal view; *e*, lateral angle of outer uropod; *f*, right mandible; *g*, right first maxilla; *h*, right second maxilla; *i*, right first maxilliped; *j*, right second maxilliped; *k*, right third maxilliped; *l*, right first leg; *m*, right second leg; *n*, right third leg; *o*, right fourth leg; *p*, right fifth leg. *a–c*, *k–p*, × 5.9; *d*, *e*, × 34.2; *f–j*, × 12.8.

dactyl. Propodus 2.8 times as long as dactyl, 1.4 times as long as carpus, and 0.8 times as long as merus. Fourth leg (Fig. 2*o*) reaching beyond antennal scale by dactyl and distal fourth of propodus. Propodus 3.8 times as long as dactyl, about twice as long as carpus, and about as long as merus. Fifth leg (Fig. 2*p*) reaching beyond antennal scale by dactyl and one third of propodus. Propodus nearly four and one half times as long as dactyl, about twice as long as carpus, and a little more than 1.1 times as long as merus.

Pleopods and uropods of usual shape. Outer branch of uropods with a movable spine on inner side of fixed tooth at end of outer margin (Fig. 2*e*).

Size.—The holotype is somewhat more than an inch long. The carapace measures 6.9 mm from the level of the posterior margin of the orbit to the hind margin of the carapace.

Color.—The collector, Robert B. Cumming, has furnished the following color notes on the specimens in life: "This shrimp was completely colorless and translucent with the exceptions noted below. There was no suggestion of any general body color except white and this was a mere suggestion. There was an organ in the dorsal portion of the cephalothoracic region which was a vivid pea green in color. This looked like an egg mass. It resembled a miniature mass of English peas with each 'pea' just under a millimeter in diameter. The gills or something in the gill region was red in color. There was not much red color and it was somewhat diffused coming through the carapace. There was a small black spot just cephalad to the green mass mentioned above when the animal was caught, but when the shrimp fed extensively on liver several days after its capture, the spot became larger and red and sometime later it became invisible."

Biology.—"Squirrel Chimney," the type locality of this species, is described by Hobbs (1942, p. 147) as "a circular solution cavity with almost vertical walls, the latter supporting a luxuriant growth of liverworts, mosses, and small ferns. This chimney penetrates the surface soil and limestone to a depth of approximately 50 feet, where it strikes subterranean water. Debris has fallen into the sink and has accumulated at the water level so that a little less than half of the bottom area is open water, the rest of it being covered with fallen leaves which are supported by dead tree trunks and limbs. Within six to eight feet of the bottom a small opening about three feet in diameter leads out into a fissure about 25 yards long and four feet wide, the whole bottom of which is filled with water ranging in depth from a few inches to 30 feet at the deepest place sounded. The light is very dim inside of the fissure, and a short distance inside of it, it is completely dark. The water is very clear, but the surface film sometimes supports a coat of fine silt and debris. The bottom consists of mud, sand, and silt, with large limerock outcrops."

Mr. Cumming has also supplied the following notes on the occurrence and habits of this shrimp. "The shrimp was taken . . . while I was swimming in open water in the fissure at Squirrel Chimney. It was not very near a wall when first seen but swimming freely. It was taken in association with [the crayfishes] *Troglocambarus maclanei* Hobbs and *Procambarus pallidus* (Hobbs) [and also a white amphipod, probably *Crangonyx hobbsi* Shoemaker]. Another trip was made on July 15, 1953, in an attempt to catch more specimens of shrimp. I swam but saw no animals of any sort. I then set traps baited with liver (the captive specimen seemed to like liver). As I was about to leave, dressed and with all of the equipment placed in a bag, I saw a shrimp swimming in open water right down the center of the fissure about 2 inches below the surface. I tried rapidly to get a mask and sieve out of the tied bag and was ready to go in with my clothes on, but the shrimp seemed sensitive to our lights, and arriving at a spot right below us, dove straight down out of sight. The only animal we saw on the 15th was a shrimp. I returned to Squirrel Chimney on the 17th of July to swim and examine the traps. Swimming, I saw many specimens of *P. pallidus* but nothing else. The traps contained a few specimens of *P. pallidus* and that was all. [Subsequently five more specimens were seen in July and early August but they all eluded capture.]

"The shrimp seemed much more at home in an aquarium than cavernicolous crayfish taken on the same day at the same locality. The shrimp swam freely about the aquarium much of the time, but it also rested frequently on the bottom. It sometimes would hang on the air hose near the surface of the water, a habit it shared with *T. maclanei* but not *P. pallidus*. The shrimp fed readily on bits of raw liver, having no difficulty in discovering the food and showing no hesitation in feeding as soon as it was discovered. This was not true of the crayfish."

Remarks.—This is apparently the first blind species of the subgenus *Palaemonetes* to be discovered. It approaches *Palaemonetes* (*Alaocaris*) *antrorum* Benedict from subterranean waters near San Marcos, Texas, in the unpigmented eyes, the armature of the telson, and the elongate appendages. It shows a close relationship to the typical subgenus and differs from the subgenus *Alaocaris*, however, in the firm integument, the form of the rostrum, the position of the branchiostegal spine, the dissimilarity between the first two pairs of legs, and the presence of a movable spine, in addition to the fixed tooth, at the outer angle of the outer branch of the uropods.

It was hoped that additional specimens might be obtained before this species was described, but the description of the species from a single specimen seems to be justified because it is so distinct from all other known species of the genus. Perhaps this record of this interesting species, the first cavernicolous shrimp to be found east of the Appalachians, will lead to the discovery of other specimens.

It is a pleasure to name this species for the collector, Robert B. Cumming. Our knowledge of invertebrate animals can be greatly enhanced by observers who display the interest and determination shown by Mr. Cumming.

KEY TO THE AMERICAN SUBTERRANEAN SHRIMPS

1. Fingers of chelate legs with dense terminal brushes of long hairs. Exopods on some or all legs. (Atyidae.) 2
   Fingers of chelae only sparsely setose. Legs without exopods 5
2. Rostrum extending beyond end of antennular peduncle and armed with small, movable spines. Carapace armed with three pairs of spines (supra-ocular, antennal, and pterygostomian) ..*Palaemonias ganteri* Hay, 1901. Mammoth Cave, Ky.
   Rostrum unarmed and not extending as far as end of antennular peduncle. Carapace completely unarmed. (*Typhlatya*) 3
3. Rostrum reaching nearly as far as distal end of second antennular segment. Epipods biflagellate ..*Typhlatya pearsei* Creaser, 1936. Caves in Yucatán.
   Rostrum not reaching as far as tips of eyestalks. Epipods simple, straplike 4
4. Exopod on fifth leg nearly as long as those on preceding legs. Telson three times as long as wide .....*Typhlatya garciai* Chace, 1942. Cave at Banes, Oriente Province, Cuba.
   Exopod on fifth leg rudimentary. Telson two and one half times as long as wide *Typhlatya monae* (see above). Mona Island, Puerto Rico.
5. Carpus of second legs multi-articulate. (Hippolytidae.) Rostrum armed with four to six teeth above and two to four below. Eyes pigmented. Carpus of second legs composed of 26 to 32 segments; merus of 12 to 17 *Barbouria cubensis* (von Martens, 1872). Cave between Morro Castle and Cojimar, Cuba (possibly extinct).
   Carpus of second legs not subdivided. (Palaemonidae.) 6
6. Rostrum laterally compressed, reaching at least as far as end of second antennular segment. Branches of outer antennular flagellum fused at base. (Palaemoninae.) 7
   Rostrum dorsally flattened, not reaching as far as end of first antennular segment. Branches of outer antennular flagellum not fused at base. (Euryrhynchinae.) 13
7. Two spines on or near anterior margin of carapace, one antennal, one branchiostegal 8
   Not more than one pair of spines near anterior margin of carapace, branchiostegal absent. (*Troglocubanus.*) 10
8. No branchiostegal groove on anterolateral surface of carapace. Mandible with 2-jointed palp .....*Creaseria morleyi* (Creaser, 1936). Caves in Yucatán.
   Branchiostegal groove present. Mandible without palp. (*Palaemonetes.*) 9
9. Rostrum armed with teeth on both margins. Two pairs of chelipeds different in size and shape. A movable spine at inner margin of terminal tooth of outer branch of uropod *Palaemonetes* (*Palaemonetes*) *cummingi* (see above). Alachua County, Fla.
   Rostrum unarmed ventrally. Both pairs of chelipeds similar in size and shape. No movable spine at inner margin of terminal tooth of uropod *Palaemonetes* (*Alaocaris*) *antrorum* Benedict. Subterranean waters at San Marcos, Tex.
10. Rostrum unarmed dorsally, or with a minute tooth near apex. An acute angle but no sharp spine below orbit *Troglocubanus inermis* (Chace, 1943). Cave in Havana Province, Cuba.
    One or more teeth on dorsal margin of rostrum or carapace. A sharp antennal spine below orbital angle 11
11. A single dorsal tooth on carapace behind base of rostrum. Lower margin of rostrum straight or concave *Troglocubanus calcis* (Rathbun, 1912). Cave in Havana Province, Cuba.
    Two or more teeth on dorsal margin of rostrum; lower margin convex 12
12. Rostrum not reaching beyond antennular peduncle, armed with two or three dorsal teeth. *Troglocubanus gibarensis* (Chace, 1943). Well entering underground stream in Oriente Province, Cuba.
    Rostrum reaching as far as, or beyond, end of

antennal scale, armed with six to eight dorsal teeth
Troglocubanus eigenmanni (Hay, 1903). Caves in Pinar del Río, Havana, and Matanzas Provinces, Cuba.

13. Rostrum reaching beyond eyes. Second chelipeds with two spines on merus and one on carpus
Euryrhynchus burchelli Calman, 1907. Well at Pará, Brazil.
Rostrum not reaching beyond eyes. Second chelipeds without meral or carpal spines
Euryrhynchus wrzesniowskii Miers, 1877. Wells and heavily shaded pools and creeks in British, Dutch, and French Guiana.

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ZOOLOGY.—*Geographical distribution and means of dispersal of the bathypelagic nemerteans found in the great submarine canyon at Monterey Bay, California.* WESLEY R. COE, Scripps Institution of Oceanography.[1] (Communicated by Fenner A. Chace, Jr.)

The bathypelagic nemerteans, which are specially adapted for life in the intermediate depths of the oceans, have been found as sparse populations in all the oceans except the Arctic north of the continents. They occur most frequently at depths of 600 to 2,000 meters, and consequently their environmental conditions show relatively little variation throughout the oceans. Since many of them are believed to be transported by deep ocean currents, information concerning their known geographical distribution is of interest to both biologists and oceanographers.

In most of the bathypelagic species the body is flattened horizontally, with much gelatinous parenchyma separating the internal organs, while in some species the specific gravity is further decreased by lipoid globules in the digestive systems. Because of the density and high viscosity of the water due to low temperature and great pressure, the worms are enabled to maintain their positions with a minimum of muscular effort. Most of the species have only feeble musculatures and many of them are presumably carried passively, with slowly undulating movements, throughout the oceanic systems in the currents and eddies which they are thought to inhabit.

Relatively little is known as to the direction and velocity of these currents, although Coe (1945, 1946) has published, with the cooperation of Dr. H. U. Sverdrup, a chart of the principal known currents of the North Atlantic at the depths inhabited by the nemerteans. The available evidence indicates that these currents have an average velocity of about 1 mile in 4 days or 90 miles per year. Comparable currents in the Pacific are even less well known although their existence is fully established.

Some of the individuals recently found in the great canyon prove to be specifically identical with those of well-known species of the Atlantic, and it must have required a very long time for their ancestors to be carried from one of these oceans to the other. It should be recalled, however, that in the late Triassic era the Atlantic and Pacific had a broad connection between North and South America.

[1] Contribution from the Scripps Institution of Oceanography, new series.

The collections were made by the personnel of the Hopkins Marine Station in connection with work on Office of Naval Research contract N6onr 25127, NR 163 901. All of them were obtained at the center of the outer portion of the great Monterey submarine canyon (lat. 36° 41′ 54″ N.; long. 122° 02′ 24″ W.), where the depth of water exceeds 1,000 meters. For each haul a 1-meter net was drawn for 1 hour after reaching depths of 650 to 1,160 meters and raised to the surface while still open. It is probable, however, that the nemerteans were caught at or near the lowest depths. This survey was conducted under the direction of Dr. Rolf L. Bolin and Dr. Donald P. Abbott, who have kindly provided the writer with the material which forms the basis of this report.

One or two nemerteans were obtained in each of 29 of the 141 net hauls at that locality made at intervals during two years. One or more representatives of 16 of the 29 species at present known to inhabit the Pacific Ocean were obtained. This is a surprisingly large number in consideration of the fact that only 57 species had been found previously in all the oceans of the world. Eight of the species, described elsewhere (Coe, 1954), are new to science, while the others had been recorded from distant parts of the Pacific and other oceans.

The geographical distribution, insofar as at present known, of each of the species in these collections is here indicated:

Family PROTOPELAGONEMERTIDAE

Plotonemertes adhaerens Brinkmann—North and South Pacific and North Atlantic.

Family PLANKTONEMERTIDAE

Tononemertes pellucida Coe—Equatorial and North Pacific.

Family DINONEMERTIDAE

Tubonemertes aureola Coe—North and South Pacific.

Tubonemertes (*Paradinonemertes*) *wheeleri* Coe—North Pacific and North Atlantic.

Dinonemertes mollis Coe—Equatorial and North Pacific.

Paradinonemertes macrostomum Coe—Equatorial and North Pacific.

Family CHUNIELLIDAE

Chuniella tenella Coe—North Pacific.

Chunianna opaca Coe—North Pacific.

Chunianna pacifica Coe—North Pacific.

Family NECTONEMERTIDAE

Nectonemertes mirabilis Verrill—Eastern and western Pacific, North and South Atlantic.

Nectonemertes primitiva Brinkmann—Equatorial and North Atlantic, Equatorial and North Pacific.

Family PELAGONEMERTIDAE

Cuneonemertes elongata Coe—North Pacific.

Cuneonemertes nigra Coe—North Pacific and North Atlantic.

Cuneonemertes obesa Coe—North Pacific.

Pelagonemertes joubini Coe—Equatorial and North Pacific.

Pelagonemertes rollestoni Moseley—North and South Pacific, North and South Atlantic, Indian and Antarctic.

The abundance and wide distribution of *Plotonemertes adhaerens* and *Nectonemertes mirabilis* may be correlated with their peculiar adaptions for sexual union, since the males of the former species have special glandular organs which are thought to enable them to cling to their mates, while mature males of the latter species have long, muscular tentacles supposedly for the same purpose. Internal fertilization may be assumed for all the species, although it has not been proved for any.

Pelagonemertes rollestoni appears to have a wider distribution than any of the other species, although the number of recorded specimens does not exceed 30. The translucent body with bright orange or red intestinal diverticula would make it a conspicuous object among the contents of the trawl.

Provided that the slowly moving currents presumably inhabited by many of the nemerteans are continuous throughout all the oceans, as oceanographers have concluded, and that they are continually transporting the populations of these worms not only throughout each ocean but also from one ocean to another, then it is conceivable that any of the species may eventually drift through the Monterey Bay area. A net lowered at the appropriate time might be expected to have a chance of catching an individual whose ancestors had lived or whose relatives are presently living in some far away part of the oceanic system.

The current systems presumably produce localized eddies where a population could remain and reproduce for a considerable time as is more fully discussed by Coe (1945,

1946). Eventually the members or their offspring may be swept again into the current system. It seems quite possible that the Monterey canyon contains, or did contain at the time that the collections were made, an eddy of this nature. But even there the nemertean population was far from dense considering the vast volume of water which passed through so many nets.

A similar intensive search has been made by Dr. William Beebe in the Atlantic near Bermuda, where nets 1 meter in diameter were drawn several hundred times at the appropriate depths through a circular area eight miles in diameter. There likewise, as reported by Coe (1945), a total of 14 species of bathypelagic nemerteans was found during the summers of 1929, 1930, and 1931, but it is uncertain whether these two examples with similar results indicate more or less permanent local populations or whether the captured individuals were drifting past those localities at the precise times when the nets were lowered to catch them. The hydrographic data indicate water movements of considerable magnitude at the depths at which the nemerteans were obtained.

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ZOOLOGY.—*A new species of the genus* Diarthrodes (*Crustacea, Copepoda*) *parasitic in a red alga.*[1] WOLF-HENRICH FAHRENBACH, University of California. (Communicated by Fenner A. Chace, Jr.).

In 1891 E. S. Barton described a curious phenomenon in which the copepod *Harpacticus chelifer* developed in the thallus of a red alga, *Rhodymenia palmata*, forming galls up to 1 mm in diameter. A similar relationship has been observed between a new species of the genus *Diarthrodes* and the red alga *Halosaccion glandiforme*. This species also represents the first reported occurrence of the genus on the west coast of North America.

In the systematic outline below the work of Lang (1948) has been followed throughout.

Order Copepoda
Tribe Harpacticoida
Family Thalestridae
Subfamily Dactylopodiinae
Genus **Diarthrodes** Thomson, 1882

Diagnosis.—Body pyriform. Epimeral plates of at least thoracic segments well developed. Rostrum not set off, directed downward. Antennule in ♀ 5–8 jointed. Exopodite of antenna 1–3 jointed. Base of mandible with 1–2 bristles (?). Exopodite of maxilla represented by 1 bristle. Exopodite of first leg not clasping, 1–2 jointed, much shorter than 3-jointed clasping endopodite. Armature of swimming legs differing somewhat from species to species. Exopodite of fifth leg in ♀ with 4–6 bristles; same for basoendopodite.

Diarthrodes cystoecus, n. sp. (Fig. 1)

Description.—The rostrum (Fig. 9) is pointed, its anterior edges being slightly concave. It is not longer than the width of the antennule and, therefore, usually hidden in side view.

The antennule (Fig. 2) is 8-jointed, the eighth, most distal, joint possibly being the expanded terminal bristle bases. All joints with exception of the first have at least 1 bristle at their distal borders. The third joint has three dorsal bristles, the fourth two long bristles at its distal edge, extending almost as far as the tip of the four terminal bristles.

The antenna (Fig. 3) is 3-jointed, with six terminal dorsally-bent bristles. Its exopodite is 3-jointed, each joint having a stiff lateral spine and the third joint an additional terminal spine.

The tapering subchela of the maxilliped (Fig. 4) has a long, slender dactylopodite and a thin bristle of at least the length of the dactylopodite emerging from the proximal portion of the hand.

[1] I am indebted to Dr. Cadet Hand for suggesting the problem as well as helpful advice and constructive criticism.

The endopodite of the first leg (Fig. 5) is 3-jointed, about twice as long as the 2-jointed exopodite, with its terminal claw being hooked and more than twice as long as the subterminal claw on the third joint. The medial bristle of the first joint of the endopodite is slightly proximal to the middle of the joint. The first joint of the exopodite has one and the second joint three heavy spines, the terminal one being as long or longer than the first and second joint combined.

The endopodite and exopodite of the second leg (first swimming leg, Fig. 6) are 3-jointed, the first and second joints of the exopodite having one spine each, the third joint three spines. In addition the second joint of the exopodite has one and the third joint four long, stout bristles. The endopodite has one spine on the first and one on the third joint plus two and four long bristles on the second and third joint, respectively.

The two other pairs of swimming legs also show the characteristic heavy spine armature of the exopodite. The fifth leg (Fig. 7) has four bristles on each side of the basoendopodite, one of these being external to the exopodite. The exopodite has five bristles, the second one counted from the medial side being more than three times the length of the exopodite.

Diagnosis.—A.1 8 jointed (?). Exp. A.2 3-jointed with one bristle on first, one on second and two on third joint. Exp. P.1 2-jointed, Enp. P.1 3-jointed, medial bristle of first joint slightly proximal to middle. Exp. and Enp. P.2 3-jointed. Exp. P.5 oval, about one-third longer than wide, with five bristles. Benp. with four bristles.

Color: Ruby-red, with conspicuous deep-red sparkling nauplius eye in life.

Dimensions: 0.5–0.8 mm long, 0.18–0.20 mm wide.

Type locality: Moss Beach, San Mateo County, Calif.

Type specimen: U. S. N. M. no. 96364 (♀).

Methods.—A new staining technique (after Mazia et al., 1953) was used with excellent results. The protein stain, mercury-bromphenol blue, can be used on any material not fixed in osmium containing fixatives. The copepods were transferred to the stain (10g $HgCl_2$ and 100 mg brom-phenol blue per 100 ml H_2O) for 15–20 minutes, then passed into a buffer of pH 6.4 (79.9 g $K_2HPO_4 \cdot H_2O$, 61.2 g KH_2PO_4, 1000 ml H_2O). While the buffer effects an immediate blueing and subsequently extracts the stain, the process can be stopped, when the desired intensity has been reached, by changing to alcohol. The result is a dense blue stain in the bristles and muscles.

Discussion.—The presence of males could not be ascertained, i.e., there have not been found any obvious structural differences between ovigerous females and other animals without egg sacs. A possible separating characteristic could be the length of the bristles of the fifth leg, although such variations and intergradations were found that I am unable to make any definite decision.

Although ecology and mode of reproduction are practically unknown for all 19 species in this genus, the few sparse bits of information almost all agree that the habitat for the genus, wherever found, is in the "zone of red algae" and "littoral zone" (Lang, 1948).

Diarthrodes cystoecus seems to be able to complete its life cycle in the same alga. Large numbers of ovigerous females are found in the organic and silty sediment inside the water-filled, bladder-like thalli of the red alga *Halosaccion glandiforme*. This alga occurs in great abundance between the 2.5′ and 1.0′ tidal level at the type locality.

The young nauplii burrow into the inside wall of the bladder. One such six-legged nauplius was found a few cells deep under the inside surface. The area of perforation was whitish and firm, apparently noncellular. As the animal grows a cyst is produced, projecting about 1 mm above the external surface, with a diameter up to 1.5

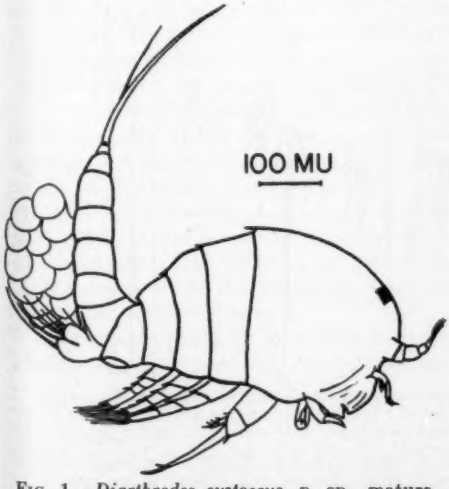

FIG. 1.—*Diarthrodes cystoecus*, n. sp., mature female.

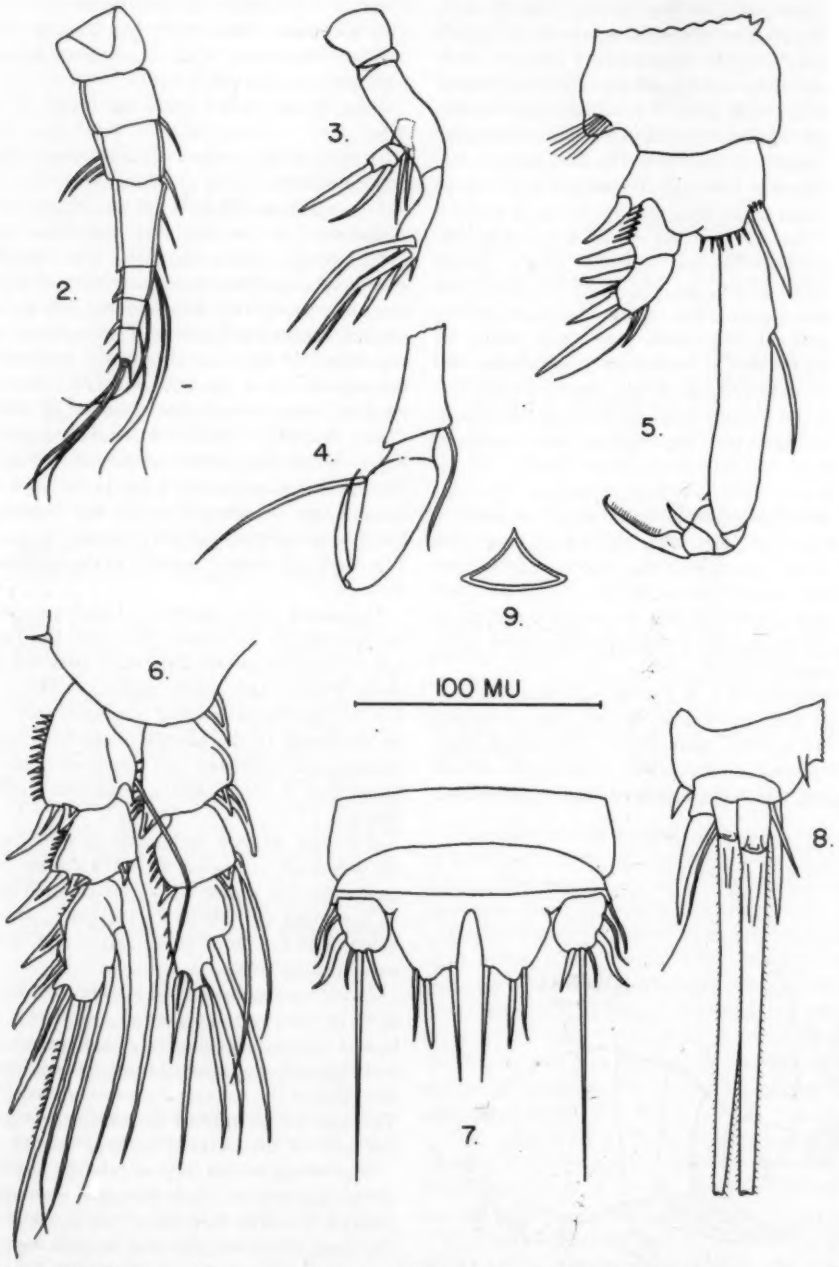

FIG. 2–9.—*Diarthrodes cystoecus*, n. sp.: 2, Antennule; 3, antenna; 4, maxilliped; 5, first leg; 6, second leg (first swimming leg); 7, fifth leg, dorsal view; 8, caudal ramus, dorsal view; 9, rostrum.

mm. On the inside there is a corresponding very slight protuberance, becoming more conspicuous and transparent as the animal grows and, finally, showing a perforation. In this stage ovigerous females were found tightly wedged in the central cavity of the cyst. Later, the perforation becomes larger and the animal is liberated into the inside of the bladder. Since most bladders have areas eroded open to the exterior, the copepods, which tend to crawl by means of their swimming legs on the surface of the alga, probably infect neighboring plants.

No attempt has been made in this study to determine the mode of reproduction, whether parthenogenetic or, possibly, by external fertilization.

About 70–80 percent of the algae at the type locality were infected. Considering the degree of infection in individual thalli there seems to be an "all or none" effect, i.e., thalli are either free from copepods or are infected to a high degree. In one instance, 33 cysts per cm^2 were counted. It seems plausible that a population in a young frond, having very few perforations, is relatively confined and multiplies rapidly. This heavy infection in most cases leads to extensive perforations of the bladder.

The habitat in the alga, as described here, is a truly admirable one. The bladders hold water for a long time, even if exposed, or stay moist due to their relatively fleshy walls. Furthermore, there does not seem to be any predator of any consequence in or on the algae.

The name *cystoecus* (cyst dwelling) suggested itself as the most appropriate one.

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MALACOLOGY.—*A study of the shell structure and mantle epithelium of* Musculium transversum (*Say*).

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(Communicated by Willis L. Tressler.)

Musculium transversum (Say) is a member of the family Sphaeriidae, a group of fresh-water bivalves that are worldwide in distribution and are found in lakes, pools, and rivers, where they occupy the shallowest of water and the lower depths of the deepest lakes. Some of the usually accepted characteristics of the Sphaeriidae include the presence of punctae in the shell material and the absence of a prismatic layer as a component of the shell. Previous studies have described the shell as consisting of only the nacreous layer and the periostracum, thereby differing from the other bivalves in which the shell consists of the periostracum, prismatic layer, and the nacreous layer.

This report is mainly concerned with the general shell structure of *M. transversum*, and evidence is presented that shows the presence of a prismatic layer as a natural component of the shell. A gross study of the mantle epithelium is also included, and a correlation of the shell structure with the mantle epithelium is attempted. The pyramidal cells, however, which occupy the punctae or shell canals, are treated lightly, and conclusive evidence as to their function is still lacking.

Schröder (1906–1907) cited Leydig as stating that the shell of *Sphaerium corneum* lacked the prismatic layer, the shell being composed only of the nacreous layer and periostracum. Leydig concluded that the punctae were hollow canals; that they were unbranched and measured 0.024 mm in length and were 0.003 mm wide; and that the mantle epithelium was composed of large cells, 0.007 mm to 0.012 mm, some of which grew into the canals. Leydig surmised that the purpose of the canals was similar to bone and tooth canals in that the purpose is to carry food materials.

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Schröder (loc. cit.) studied the structure of the shell and mantle epithelium of *Musculium lacustre*; he seemed to follow Leydig in that the shell lacked the prismatic layer. He described the mantle epithelium as consisting of (1) large, flat polygonal cells with conspicuous spherical nuclei, mostly peripheral in location, and (2) pyramidal cells with irregular bases located between the large polygonal ones. The tips of the pyramidal cells appeared as if drawn out into long processes that measured 0.003 mm to 0.060 mm in length, depending, of course, on the thickness of the shell; these processes extended through the shell canals and ended at the periostracum. He also recognized a finely coiled thread inside these processes which ended either on the periostracum or on a sort of a button above the periostracum. He thought that the cells might have a glandular function, but when he considered their position this assumption was rejected, mainly because it would seem strange to interpret them as secretory since they were not located at the edge of the mantle. Schröder did not deny the possibility that the cells were sensory in function; however, his work was interrupted before he observed any supporting evidence on this detail.

Schröder (loc. cit.) also pointed to the mantle papillae of the brachiopods, and cited Von Blochman, who surmised that the papillae were concerned with the secretion of the shell. Schröder did not speculate, however, on the extent to which the brachiopod papillae could be compared with the pyramidal cells of *Musculium*.

Oveinnikov (1931), in studying the shell structure of *Sphaerium corneum*, stated in agreement with the above workers that the punctae do not go through the shell to the exterior.

MATERIALS AND METHODS

Sections of the shell used in the study were prepared by a method long used by paleontologists in studying the structure of various fossils. A mounting medium, known as Lakeside 70, was melted on a glass microscope slide. A small hotplate was used for heating purposes. One of the valves or a shell fragment was set upright in the medium, and two pieces of matchsticks were used to stabilize the valve or fragments in upright positions. The slide was then removed from the hotplate, and the Lakeside 70 was allowed to cool and harden. Then the shell was ground, with a circular motion, against a flat piece of glass pane onto which moistened grinding powder (#600) has been placed. After a smooth, flattened surface was fashioned, the slide was washed off, dried, and placed back on the hotplate to remelt the Lakeside 70. Following this the matchsticks were removed and the ground, flattened surface of the shell was turned over and placed flat against the surface of the slide. The latter was removed from the hotplate, and the mounting medium was allowed to re-cool. The unground side of the valve or shell fragment was then ground with a circular motion, as before, against the glass surface. While the fragment or valve was being thinned down, frequent cleaning and examination of the object was necessary to prevent grinding the section too thin. When the grinding was completed and the slide thoroughly cleaned with running water, and dried, a coverslip was cemented with Permount over the section to prevent any possible injury.

These ground sections were studied with compound microscope and polarizing microscope. The polarizing microscope was necessary for determining the orientation of the calcite crystals of the shell.

OBSERVATIONS AND DISCUSSION

Mantle epithelium and punctae.—Gross examination of the young clams and embryos of *M. transversum* showed that the pyramidal cells of the mantle send projections through the thin embryonic shell (see Fig. 1). Individual embryos and young were of varying sizes when the projections first appeared. The largest individual studied (an extramarsupial embryo)[2] in which the projections had not yet appeared measured 1.63 by 1.25 mm (length by height); the smallest individual measured with these projections was a 1.29 by 1.02 mm young clam.

Projections from the mantle epithelium appear first as slender rods, and those projections measured ranged in length from 0.009 to 0.045 mm, whereas the diameters varied from 0.003 to 0.009 mm.

Shortly after the projections appear on the surface of the shell, the thin, almost transparent shell becomes opaque, and the surface of the valves acquires a wrinkled appearance. This wrinkled appearance is due to formation of raised, polygonal areas, each having a projection in the center or near the edge. These areas are

[2] According to Okada (1935), an extramarsupial embryo is one that has been liberated from its marsupial sac and is capable of free movement about the inner branchial chamber.

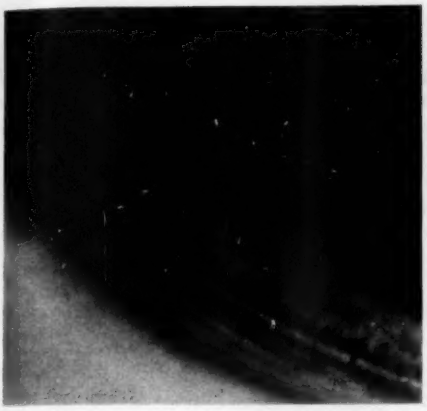

FIG. 1.—View of exterior surface of a young clam less than 3 mm in length. Note the projections along the ventral margins of the valve.

thought to be the bases of the crystal structure of the calcareous material of the shell. (This will be discussed later).

Examination of the ground sections of the adult and young shells shows that the shapes and sizes of the punctae closely resemble the projections that were described above. The openings of the punctae on the innermost surface (see Fig. 2) prove to be much wider than the slender, tubular portions of the punctae, with those measured varying from 0.012 to 0.018 mm. The slender, tubular portions of the punctae measured 0.003 to 0.009 mm in diameter (see above measurements of the diameters of the epithelial projections), thereby duplicating the diameters of the projections which they actually enclose. Lengths of the punctae vary with the thickness of the shell, with the larger adult shells being the thickest. These measurements also closely resemble the measurements of the pyramidal cells and punctae of *Sphaerium corneum* and of *M. lacustre* (see above).

Relationships of the punctae with the periostracum seem to vary with the individual punctae. Some terminate in raised plugs near the top of the periostracum, while others appear to end as pointed projections in the periostracum. Only a few extend up above the periostracum, but they seem to be covered with periostracum even though they extend above its general level. In a given plane of section, parts of punctae can be seen at different levels, which is due to the curvature of some of the punctae.

Shell structure.—Study of the ground sections of the shell of *M. transversum* shows that the shell consists of a nacreous layer, a prismatic layer, and periostracum (Fig. 3). Evidence that the layer shown between the periostracum and the nacre in Fig. 3 is actually prismatic was obtained by use of a polarizing microscope. By this means the crystals of the prismatic layer were seen to be oriented perpendicular to the laminated layer of the nacre. The identification of the prismatic layer proves that the shells of *M. transversum* agree with certain other pelecypod shells such as the Naiades (pearly fresh-water mussels) in possessing three fundamental layers in the shell.

The periostracum in a given section varies in thickness, measuring 0.003 to 0.009 mm in those observed in this study. In a given section, the prismatic layer varied in thickness also, measuring as much as 0.15 mm in the hinge region and as little as 0.027 mm in the middle of the valve where it seems to be the thinnest. The nacreous layer ranged from 0.009 to 0.069 mm in thickness, being the thinnest in the hinge and near the ventral edge. Of course, it must be taken into consideration that the measurements of each shell layer vary in thickness according to the size of the individual studied.

It is usually accepted that glands located on the ventral edge of the mantle secrete the prismatic layer and that the nacreous layer is secreted by cells of the general mantle surface. This may not be the case with the sphaerids since observations of the pyramidal cells and punctae tend to indicate a relationship with the prismatic layer. Pyramidal cells are not thought

FIG. 2.—View of the inner surface of the shell showing the openings of the punctae into the shell. The openings appear as dark circles.

to be concerned with the formation of nacre since the pyramidal cells appear (grossly, that is) only after the nacreous layer is formed.

As mentioned before, the whole surface of the embryonic and young clam shell assumes a wrinkled appearance after the projections of the pyramidal cells protrude through the shell. This wrinkled condition was interpreted as being caused by the formation of raised, polygonal areas, each of which had a more or less centrally located projection. As stated before, these areas are thought to be the bases of the calcareous crystals of the prismatic layer. In other words, there appears to be one of the punctae with its corresponding pyramidal cell process piercing each polygonal prism of the prismatic shell layer. If this assumption is correct, then the pyramidal cells may be concerned with the secretion of the crystals of the prismatic layer. Such a method of secretory activity, however, does not conform to the generally accepted description of the secretion of the prismatic layer in other bivalves.

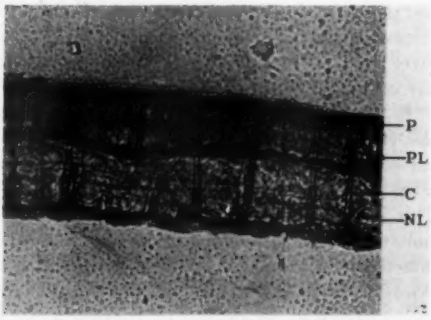

FIG. 3.—Ground section of the shell of a mature clam showing the periostracum (P), the prismatic layer (PL), the nacreous layer (NL), and the punctae (C) which traverse the calcareous layers of the shell. Some of the punctae appear discontinuous due to their curved shape. Note the laminations in the nacreous layer and the blurred line that separates the prismatic layer from the nacreous layer.

SUMMARY

Gross examination of the young and extramarsupial embryos of *Musculium transversum* shows that the pyramidal cells of the mantle send projections of material through the thin embryonic shell. The smallest individual exhibiting the projections measured 1.29 by 1.02 mm; the largest individual observed without the projections measured 1.63 by 1.25 mm.

The calcareous material of the shell surrounds the projections, forming the canals or punctae.

The punctae terminate in the periostracum either as plug-shaped structures or as pointed projections.

A study of the ground sections of the shells shows the presence of a nacreous layer, a prismatic layer, and a periostracum. The presence of a prismatic layer has been heretofore overlooked by students of this family.

The punctae and pyramidal cells of the relatively thin, fragile shell of the Sphaeriidae might possibly indicate a relationship with the secretion of the prismatic layer. Such a method of secretory activity, however, does not conform to the generally accepted description of the secretion of the prismatic layer in other clams.

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